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TESTS OF INTELLIGENCE
AND APTITUDE

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TESTS OF INTELLIGENCE AND APTITUDE

Part II of the Report of the Committee on Character Tests and Psychological Tests: Katharine B. Greene, Paul R. Mort, Goodwin Watson, and Harry J. Baker, *Chairman*.

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FOREWORD

As was remarked in the foreword to the preceding number, the topic of psychological tests has been divided. Tests of personality were treated in the June number, and tests of intelligence and aptitude are dealt with in the present number. This separation was necessitated by the extensive literature which has accumulated during the past few years dealing with tests of personality. The expansion in this field is comparable to the expansion in the field of intelligence testing ten to fifteen years ago. If we may judge from previous experience, the period of rapid multiplication of personality tests is now nearing its close and the period of critical evaluation is opening. If this inference is correct, the evaluation of personality tests will be a prominent feature of the report on tests in the next cycle, three years hence.

FRANK N. FREEMAN,
Chairman of the Editorial Board.

INTRODUCTION

THIS DISCUSSION of psychological tests involves a number of important problems. One of these is the highly complicated nature of the abilities which psychological tests measure. The nature of general intelligence and of special abilities and disabilities is presented as an introduction to this number of the *Review*. There follows the nature and extent of individual differences in various groups and populations in both general and special intelligence. A brief presentation of test construction and statistical technic is then offered to show how tests are molded and affected by factors other than the traits which they are designed to measure. Problems of test construction and the theoretical phases of psychological tests are sufficiently complicated and technical to engross the entire attention and interest of psychologists, but in this review they represent only one phase of the entire problem. The discussion continues with a survey of the application of test results to normal and atypical groups and closes with a brief consideration of vocational aptitudes tests.

The value of psychological tests depends largely upon their proper application to various populations and upon the modifications in educational and social procedures that result from their use. Testing programs determine the need for changes which psychologists are not always equipped to make, nor are their interests always pointed in that direction. On the other hand, administrators and teachers are sometimes conscious of needed changes, but either feel that this is not their responsibility, or that the psychologists should complete the changes which seem necessary. Lack of progress is the obvious result. The committee feels that along with further improvements of testing technic and test construction must come a better understanding and mutual interest in the revision of educational procedures.

The committee has found difficulty in selecting a limited number of references from a very large field. In some cases where several investigators have reported on similar investigations, the authors have been listed in the text without bibliographic references.

HARRY J. BAKER, *Chairman,*
Committee on Character Tests and Psychological Tests.

CHAPTER I

General Intelligence and Its Measurement

GENERAL INTELLIGENCE and methods used in its measurement are presented in this chapter. The historical background of mental measurement is followed by a discussion of the nature of general intelligence. A résumé of selected references dealing with current theory and practice in intelligence testing then leads to a brief presentation of verbal and non-verbal tests. A note on test terminology closes the discussion.

History of Mental Measurement

The history of mental measurement as a field of specialized interest in psychology has been treated in a number of textbooks concerned with practical discussions of individual differences in mental ability. In spite of differences in matters of detail, there is a certain uniformity in the selection of beginnings, in emphasis, and interpretations. Examples of good discussions of the history of intelligence testing appear in books by Bisch (8), Freeman (34), Peterson (75), and Young (109). Pintner (78) issues a yearly review of current literature in the *Psychological Bulletin*.

In general, the modern development of tests is traced back to work published in the last two decades of the nineteenth century: by Cattell, on the measurement of individual differences in simple sensory and motor processes; by Ebbinghaus, on the completion test as a measure of intellectual capacity; by Galton, on research in hereditary factors in ability; by Gilbert, on the validity of measures of general intelligence determined by comparing test results with estimates of ability; by Münsterberg, on logical analyses of abilities, but without statistical treatment; by Oehrn, on a system which would graph an individual's ability in a profile of scores on tests whose values were determined by a simple correlation technic; and by other pioneer workers such as Wissler, Jastrow, Bolton, and Binet.

In the early years of his experimental work Binet followed the traditional line of approach with its theoretical analysis of intelligence. However, when he was assigned the task of selecting candidates for special subnormal schools in Paris, he met a practical problem that gave new direction to his work. To solve this problem he began to combine tests of many types into a single scale. The very hodgepodge of single tasks which he put together favored him in getting a fairly good measure of general ability. His success diverted attention from the measurement of specific abilities and led to a concentration of interest on the part of many psychologists on the new problem, the measurement of general mental ability. As a result, Binet's technics have been greatly refined. In addition to his scales of 1905, 1908, and 1911, Binet made two outstanding contributions to the

theory of psychological measurement. He developed, first, the concept of general intelligence; and second, the concept of mental age. The use of the concept, intelligence quotient, to denote relative rates of development, formulated by Stern and popularized by Terman, gave new clearness to the concept of mental measurement for many persons. Binet's influence is reflected in the many revisions of the Binet-Simon Test which have appeared; for example, that by Bobertag in Germany, 1913; Decroly and Degand in Belgium, 1910; Johnson in England, 1911; and American revisions by Goddard, 1911; Herring, 1922; Kuhlman, 1912 and 1922; Terman, 1913 and 1916; and Wallin, 1911.

The movement for individual measurement of general ability fused with the development of tests for measuring single traits. Special tests, on account of their limitations in general interpretations, were overshadowed. With the development of new series of tests other advances were achieved. Statistical techniques were developed to the point where every test could be required to meet definite standards with respect to validity and reliability. With the growth of emphasis on the correlation method as a technic for the selection of valid and supplementary tests, an individual point scale was developed by Yerkes in 1915. This was soon followed by many group point scales of intelligence.

Nature of General Intelligence

The nature of general intelligence has been studied by many workers. A summary of early studies in this field is given in the *Twenty-first Year-book* of the National Society for the Study of Education, 1922 (69).

The psychologists, particularly the physiological psychologists, have been very active in this field. Child (17), Herrick (45), and Lashley (59) developed certain common general principles which are assumed to govern, not only gross physiological growth, but also intelligence. Lashley's work called in question an hypothesis that had been widely accepted, namely, that reflexes are isolated conduction paths. He found that cortical functions utilized in learning to run mazes were not dependent on the existence of specific neural patterns in the cortex. Experimental destruction of cortical areas in rats did not show any specific area which must be kept intact in order to develop or preserve a particular mental function. He inferred that (59: 176) "the mechanisms of integration are to be sought in the dynamic relations among the parts of the nervous system rather than in details of structural differentiation." His work pointed toward a theory of the nature of these forces. Its bearing on the nature of intelligence may be summarized in his own language (59: 173-74):

[These experiments] lend support to the theory which conceives intelligence as a general capacity, in the same measure that they oppose theories of restricted reflex conduction. The capacity to form and to retain a variety of maze habits and other less well-defined habits seems relatively constant for each individual, dependent upon the absolute quantity of cortical tissue functional and independent of any qualitative

differentiation of the cortex or sensori-motor peculiarities of the problems solved. There is an indication that difficult tasks become disproportionately more difficult with decreased cerebral efficiency. Such facts can only be interpreted as indicating the existence of some dynamic function of the cortex which is not differentiated in respect to single capacities but is generally effective for a number to which identical neural elements cannot be ascribed. In this there is close harmony with theories of a general factor determining efficiency in a variety of activities. The diverse results obtained in the studies of problem boxes and brightness discrimination show that this factor is not universally effective.

Discrimination of amounts of learning ability among individuals led to consideration of the cause of these differences. Educational psychologists became vitally interested in a practical interpretation of differences, their causes and their educational possibilities. An essential problem was the prediction of certain traits through the measurement of other traits. Psychologists soon discovered that simple acts or an individual's fund of common information could be measured with comparative ease. Such measurements had circumscribed value, however, until it was demonstrated that there was a dependable relation between functioning in the measured trait and functioning in other traits and at other levels of integration.

Thorndike (99) studied the relationship between the amount of work which an individual could do on a single level (area), the difficulty of tasks which he could perform (altitude or level), and the number of units of work which an individual could produce in a given time (speed). He set up new standards for intelligence, since he found that in tests of known level, with performance of measured area and speed, he could reconstruct the intelligence of each subject, other things being equal. Furthermore, Thorndike found a high positive correlation for these three aspects of intelligence as defined and measured. With regard to intelligence in its larger aspects, "the ability to deal with things or persons or ideas by the use of ideas," he proposed the hypothesis that all intellectual operation is identical with the processes of association—that higher operations simply require more associations. Although admitting the possibility of a single cause of individual differences in intelligence such as *vitality*—as some had proposed—Thorndike preferred the hypothesis that the degree of intelligence is increased by each increase in the number of connections between ideas.

Thorndike's work finds support in that of Tilton (101). Further analyses of intelligence in terms of speed of activity were made by Peak and Boring (74).

Spearman (88) analyzed intelligence, making large use of statistical methods. He stated that to regard the average score of the individual on a series of trait tests as representative of the average of the person's abilities is to go beyond knowledge and sensible assumptions, since to do so assumes that each test measures exactly the amount and importance of each trait in the individual's make-up. Since no sound analysis of mental organization into comparable units existed, Spearman sought to determine the contribution of specific traits to general intelligence by statistical study of the

results of tests when varying amounts of specific traits were represented in the composite tests. His method of analysis, the tetrad difference method, made use of the intercorrelation of various traits. Spearman found that when correlations between four tests are calculated by pairs so that each test of the first pair is correlated with each test of the second pair, a significant relation often exists so that the product of any two correlations is equal to the product of the other two correlations. After subjecting this statistical procedure to searching mathematical analysis, Spearman interpreted the observed relationship to mean that a common factor, which he designated as "G," is measured in each trait. The amount of influence which "G" exerts on each of several traits was calculated by Spearman and others. On these findings he erected a hierarchy of traits from those which are little influenced by "G" to those which are heavily weighted by it. While "G" may be called *intelligence*, Spearman did not define it except to indicate that energy in the form of a common factor does exist. In his later analyses, he postulated four general factors in performance: "G", mental inertia, oscillations of mental efficiency, and self-control. Of these, only "G" manifests appreciable individual differences. He also studied "S" factors, the specific elements in intelligence. When a knowledge of "G" and "S" factors makes it possible to construct tests which will measure "G" and "S" at the maximum, an accurate measure of "G" for any individual can be obtained. This, Spearman maintained, was far better than an average derived from a miscellany of unrelated traits.

Thompson (96) and Thomson (97, 98) evaluated the tetrad difference criterion. The latter stated that it did not necessarily prove the existence of two factors, since a theory of multiple factors would explain it as well.

Courtis (22) studied the nature of intelligence giving particular attention to the problem of rate of mental development. Three natural factors affect the growth of intelligence: (1) the initial development of the organism, or the starting point, which Courtis identified as the "S" in Spearman's theory; (2) the maximum to which the individual grows, also specific and the effect of heredity; and (3) the quality of the organism, which determines the rate of growth in a given environment, identified as Spearman's "G" factor. Because of the interaction of all these in learning, rate of growth can be measured only by the use of growth units which enable one to determine the effects of the three factors separately. Courtis sought more appropriate units for growth measurement than those already in use, and after making a series of measurements, developed certain hypotheses concerning mental growth. He found that growth proceeded at a uniform rate under uniform conditions when measured in the units which he had employed.

For many years Dodge (28) carried on intensive laboratory work on the problem of human variability. He concluded that before each response to a situation there was a combining process in the nervous system, so that successive responses to the same overt stimulus varied according to the con-

ditions within the nervous system. This he found to be true at both lower and higher levels of mental integration. He summarized the function of general intelligence in this combining process as follows (28: 107):

Our picture of human adjustment is not a mosaic of reinforcing or conflicting reflexes, instincts, habits, and voluntary acts, or a succession of discreet responses under these various categories, but a dynamic continuum, a sort of spiral process with a relatively simple front of overt reaction at any given moment and a highly complex background. Adequate experimental analysis would probably show that each overt reaction is really a complex of approximate beginning reactions and elaborated adjustments. The beginning reactions are evoked by current stimuli superposed on the remains of consummated responses to past stimuli by which they are inhibited, reinforced, or qualitatively modified.

This statement proposed, not only a basis for the nature of general intelligence, but also gave an explanation of the cause of variability in response, a problem which had been troublesome in the building of a theory of a single factor in general intelligence. In further elaboration Dodge said (28: 134):

Persistent cortical systematizations are discoverable in all perceptual and thinking processes, but they are not constants. On the contrary, they are modified more or less by every related experience and behavior, and subject in successive instances of their arousal to all the modifying influences of refractoriness, inhibition, reinforcement, relative fatigue, and re-systematization. In a unique way they appear at the very heart of our consciousness and behavior.

Peterson reviewed Spearman's and Thorndike's analyses of intelligence and concluded that (75: 273):

There can be little doubt that a somewhat median position between the extreme early views of Spearman, on the one hand, and of Thorndike, on the other, is nearer the truth. Neither view seems to be supported by a consideration of the neuromuscular bases of behavior. At any rate, that intelligence is associated with biological structures which are complete in development at a comparatively early age—at about sixteen years of age—may now be regarded as established.

Kohs reached still another conclusion concerning the nature of general intelligence. He said (56: 10):

Differences in level of mental ability may some day be explained, among other things, on the basis of differences in fundamental synthesizing ability, or the capacity of the nervous system to fuse elementary states of consciousness into higher thought forms.

Kelley (53) adopted Spearman's method of determining the number of common factors, namely, the statistical analysis of test results. Kelley derived criteria for determining the number of common factors present. He argued that these common factors may vary in number and also in effectiveness on test scores and that their influence can be measured. A few of the common factors which he assumed to exist are verbal ability, memory, and interest. He also found that certain group factors were at work. Kelley's

analysis gave a new meaning to the term *general intelligence*. Meili (66) supported Kelley's findings with his own data, then used Gestalt concepts to explain results. A general and theoretical discussion of intelligence has been given by Richet (81). Claremont (18) found, through an analysis of intelligence as the ability to perceive causal relations, that not only man but animals may be intelligent.

Hull (49) and Thomson (97, 98) reached similar conclusions with regard to the existence and nature of group factors in human behavior. The Minnesota investigation of mechanical aptitude (73) indicated an absence of any general factor, although it seemed to indicate the presence of certain group factors. Four such group factors are felt to be unique: mechanical ability, intelligence, agility, and height.

Data have been reported and analyzed in numerous other writings of which the following are representative. Böge (10) analyzed practical intelligence into analysis, synthesis, and functional reactions. His methods of measurement did not isolate these parts, but he tested them in simply organized situations. Cornell (21) studied the practical effect of trait differences in educational situations. Dodd (26, 27) considered similarities and distinctions in the theories of Spearman and Thomson. Freeman (35) showed by experimental methods that "improved environmental conditions result in a significant improvement in intelligence (as measured by the tests)." Holzinger (47) supported the contentions of Spearman, using Thorndike's measurements of intelligence for the data of his statistical interpretations. Hull (50) found that an individual's variability with respect to thirty-five different traits was distributed approximately according to the normal curve. Kelley (54) analyzed searchingly the theoretical nature of "G". Spearman (89, 90, 91) presented his conclusions and pointed out the divergence of his theory from those held by other investigators.

Laycock (60) utilized Spearman's analysis of ability and built a series of measurements of adaptability to new situations to comply with these specifications. Slocombe (86, 87) endeavored to apply the concept of "G" to test data to find a measure of the accuracy and value of the tests, both for the measurement of "G" and for an explanation of variations in test data. Strasheim (94) constructed a scale of tests in keeping with Spearman's analysis of factors in intelligence.

Other questions with regard to the relation between existing measurements and the true nature of intelligence were studied by Cannon (15), Commins (19), Pintner (76), and Wilson (108).

Intelligence Testing

Freeman (34) discussed the group and individual tests which were available in 1926. Pintner (77), in a similar comprehensive textbook, presented both theoretical and practical considerations with respect to intelligence testing. Hildreth (46) compared tests as to their practical

usefulness in a school's testing program. Her manual is valuable for school executives and specialists. Dougherty (29) issued a monograph dealing critically with group tests in comparison with each other and with the Stanford Revision of the Binet Test. In it, tests are ranked on the basis of their agreement with each other. Raw scores were used in Dougherty's comparisons. Group tests were also critically reviewed by Gambrill (36), McGraw and Mangold (64), and Sangren (83). A series of short articles, dealing with various group tests, scores made, and the interpretation of results for classroom use, are given in a volume edited by Bell and Suhrie (7).

In the field of individual tests, books by Bronner (11), Burt (14), Pintner (77), and Wells (106) made important contributions. Particular tests were evaluated by Bell and Suhrie (7), Böge (10), Cannon (15), Cornell (21), Davey (24), Goodenough (38), Robinson and Robinson (82), Spearman (88), and Strasheim (94).

Conditions other than intelligence which affect test scores were studied by Brooks (12), Conrad (20), Fox (33), Spearman (88), Weston and English (107), and Wilson (108). This problem was also discussed in the report dealing with the Minnesota Mechanical Aptitude Tests (73). Marine (65) found that familiarity with the examiner made little difference in the test scores of subjects tested individually.

Practical criteria for evaluating tests were given by McCall and Bixler (63). They also presented methods of applying information gained from tests in student guidance and personnel administration. Hughes (48) pointed out certain relations between general and specific trait characteristics. Oates (72) developed the age-maturity criterion.

Graf (41) reported an ingenious method for standardizing tests. Selecting a particular age group—twenty year olds—he so standardized his test that an individual's score could be compared with those of individuals having had similar educational experiences.

A publication by Saunders and Putnam (84) gave a popular presentation of intelligence tests together with an explanation of their purpose. An excellent manual of tests for French-speaking nations was written by Decroly and Buyse (25).

Verbal Tests

The psychological examination of men in the national army during the World War gave great impetus to the development and use of group intelligence tests. Army Alpha was the first verbal group intelligence test to be used widely in the United States. It was soon followed by others; for example, the Otis Test in 1918, the Pressey Test in 1918, the Haggerty Test in 1919, the Whipple Test in 1919, and the National Intelligence Test by affiliated psychologists in 1920. Different forms of the Kuhlmann-Anderson Group Test (58) made it adaptable for use in all grades from the first

to the twelfth, and for use with adults. Among other well-known tests are the American Council Psychological Examination, the Brown University Psychological Examination (designed by Colvin), Mentimeters (by Trabue and Stockbridge), the Miller Mental Ability Test, Roback Mentality Tests for Superior Adults, the Terman Group Test of Mental Ability, Thorndike Intelligence Examinations, Thorndike's CAVD Scale, and the Thurstone Psychological Examination for College Freshmen. Thorndike's CAVD Tests are graded to fit various levels of development. They are more extensive than the majority of test series developed for practical use.

A group intelligence test was developed by Cattell (16) in England, using tests that correlated well with the "G" criterion. Davey (24) also developed a test series in England. She recommended the use of pictorial tests. Siegvald (85) described another series of tests developed in Europe and reported their successful use in schools.

A number of tests involve both the measurement of intelligence and that of achievement in school subjects. Examples of such tests are the Illinois Examination, the Otis Classification Test, the New Jersey Composite Test, and the Pintner Mental-Educational Survey Test.

The most widely used of the verbal individual tests were cited above in connection with the work of Alfred Binet. They are, for the most part, revisions and adaptations of the Binet Test.

Non-Verbal Tests

Group tests of a non-language type have been developed for use with children too young to read and for use with illiterates or handicapped readers. As in the case of verbal tests, the first widely used non-language test, Army Beta, was developed for use in the national army. Other non-verbal tests soon appeared; notably those by Myers, Pintner, Thorndike, and Dearborn. Myers' Mental Measure was a non-language test designed for persons of all ages. The Pintner Non-Language Test was designed for children in the upper grades who could not be tested fairly with verbal tests because of language handicaps or other disabilities. The Thorndike Non-Language Test was designed for adults. Dearborn's test was developed for use with children too young to read.

A number of tests designed for young children are not entirely non-verbal, particularly when they are intended for primary children at various age and grade levels. Since they make large use of non-language technics, however, they are summarized at this point together with those that are strictly non-verbal in character.

Goodenough (39) developed a single test for the measurement of intelligence through children's drawings. The drawing of a man is rated on the basis of the presence or absence of details according to standards developed. Van Alstyne (104) constructed a picture vocabulary test for pre-primary children. Reports on other tests for young children were given by

Baldwin and Wellman (4), Bayley (5), Goodenough and Anderson (40), Hallowell (44), Hutt (51), Linfert and Hierholzer (62), Murchison (67), and Newell (71).¹ Test series designed for a somewhat larger age and grade range were reported by Bühler (13), Cunningham (23), Gesell (37), Kuhlmann (57), and Stutsman (95). California, Minnesota, and Stanford universities are working on thorough standardizations of new test series.

Among other tests for pre-school and primary children are the Cole-Vincent Group Intelligence Test for School Entrance, the Detroit First Grade Intelligence Test, Haggerty Intelligence Examination, Delta 1, Myers' Pantomime Group Intelligence Test, the Otis Group Intelligence Scale, Primary Examination, and the Pintner-Cunningham Primary Mental Test.

The paper non-language tests, as illustrated in the one developed by Baker (3), provide a method of measurement for children who cannot be tested in the regular manner. Work on an international test, a non-verbal test sponsored by the National Research Council, represented a new departure in test development. Squires' (92) work on a universal test was an interesting attack on the same problem, namely, that of measuring the intelligence of various national groups with a non-language test. The Michigan Non-Verbal Test (42) was published in 1930.

A non-verbal system of tests suitable for persons from six years of age to adulthood was worked out by Vabalaz-Gudaitas (103). The entire series makes use of the same materials and requires simple motor responses. The authors' analysis of the functions tested differs from analyses commonly given in the United States. Discussion of the results by American students may lead to different conclusions.

Many of the non-verbal tests make no use of pencil and paper. These tests, which are called performance tests, give the subject materials to manipulate. Illustrative tests of this type include the Arthur Point Scale, re-standardized in 1928 (2), the Dearborn Formboards (11), the Ferguson Formboards (11), the Healy-Fernald Test Group (11), Kelley's Construction Test (52), Kent and Shakow Formboards (55), the Knox Test Group, including the Knox Cube Test (34), the Kohs Color Cubes (56), the Lincoln Hollow Square (61), the Pintner-Paterson Performance Tests (79), and the Porteus Maze (80).

Drever and Collins (30) developed a performance test for use in measuring the intelligence of the deaf. They found that the deaf did better on the test than normal children selected for comparison.

Recently Arnstein, Hertzner, and Kusching (1) and Blacking (9) worked on the standardization of tests of bead stringing. Beigel (6), as shown in

¹ The writer is indebted to Dr. Bessie Lee Gambrill for access to an unpublished bibliography covering recent research in child psychology.

a publication from Utrecht, utilized performance tests to measure the ability to combine or integrate. Böge (10) used performance tests to analyze the kind of "practical intelligence used in the solution of everyday problems."

An earlier report by Gaw on the vocational uses of performance tests was continued in a publication by Earle, Milner, and others (31). Pater-son (73) reported results obtained with the Minnesota Paper Formboards Test. General discussions of the use of performance tests are those published by Murdoch (68) and Turner (102).

Test Terminology

Terms used in connection with intelligence and its measurement have been somewhat more clearly defined during the past few years. An article by Warren and others (105) gave an analysis of psychological terms which was useful in clarifying a number of them. Another useful publication was the *Dictionary of Psychological Terms* prepared by English (32). It is intended to give the layman and beginner an understanding of the more common meanings attributed by psychologists to words used technically. Although it does not satisfy all schools of psychological thought, it is well edited. Thurstone's (100) discussion of mental age helped to clarify the meaning of that term. Spearman (90) discussed an interesting issue with regard to our psychological vocabulary.

In spite of the useful helps cited above, psychology suffers from the numerous confusions in meaning which arise. Many authors find it necessary to explain and define their terms and concepts before reporting experiments and interpretations. Thus, Greene and Jorgensen (43) have a glossary in their text, and Kuhlmann (58) defined his own terms and explained a number of concepts not in ordinary use.

CHAPTER II

Special Abilities and Disabilities and Their Measurement

ALTHOUGH major emphasis has been placed on tests of general intelligence during the past few years, considerable attention has been given to the development and evaluation of tests of particular abilities. This chapter deals with the nature and measurement of special traits.

Nature of Special Traits

Kelley (154: 8) pointed out that it was essential to the growth of scientific psychological knowledge that we know with increasing precision facts about special traits and their relation one to another. In his work, he was primarily interested in the relations between traits. Through a study of these relations he endeavored to differentiate traits which were independent but whose independent existence had not been proven. The higher mental processes fell within the scope of his studies. By statistical analysis Kelley concluded that several factors were common to two or more traits but that they were not necessarily the same in all the traits. He set up for further study the following factors: maturity, sex, race, verbal facility, perseveration, and oscillation. His proposed method of attack was to gather all available facts concerning a certain test population and then to work out in detail by statistical analysis the relation between the several traits. This method has much to commend it although at the present time it may not be practical. There is some question as to whether we can measure with sufficient accuracy all the factors entering into the performance of a test population.

The precise work of Dodge (129) was concerned only with a few subjects carefully trained for especial observations. His laboratory technics were exemplary, while still more important were his masterly analyses and syntheses dealing with the theory of special traits. Were all our data for different aspects of behavior as carefully collected and as well organized theoretically, statistical measures could be applied, and whatever relations were found among the traits could be interpreted with assurance. Significant improvements in technics of measurement indicate that in the future the technic of statistical analysis will have increasing value.

Many attempts have been made to measure traits as though they were independent. The skill with which the studies have been set up has varied with the workers' understanding of the interrelations of traits. Considerable confusion as to just what was measured has often resulted. Frequently the bit of mental life considered as a special trait has been abstracted for some special purpose, or for some particular theoretical or practical need. The measurement of the trait as independent has been declared successful in

terms of its accuracy in meeting that need, regardless of any proof as to the independence of the trait itself.

As technics for trait measurement and genetic studies develop, those which are discriminative can be selected pragmatically. Traits can then be studied by statistical methods alone or in combination. Pioneer studies of that type were made by Courtis (124), Kelley (154, 156), Paterson (186), Spearman (199, 200), Thomson (201, 202), Thorndike (203), Thurstone (205), and Toops (207).

The meaning of special traits and the relation of special traits to general ability is discussed in *Foundations of Experimental Psychology*, a book edited by Murchison (183). Liebman's (170) work, general in character, is an interesting theoretical discussion. Both Dearborn (127) and Scheidemann (191) considered the nature of special ability in their books. The latter was more concerned with tests and with a practical exposition of our present knowledge. Articles by Cannon (119), Hughes (145), and Robinson (188) reflect the widespread interest which exists in interrelations between specialized traits and general ability. They also describe useful technics.

Measurement of variability in traits, the relation of variability in one trait to variability in another, and the significance of variability as a mental characteristic have all been studied. Commins (122) brought out clearly the importance of studying test scores to secure data on the variability of the subjects. Foran, Lillis, and O'Leary (133) studied trait variability. Methods of expressing variability were studied by Thurstone (206), as well as by Anderson (111) and Heinis (141). Variability as a characteristic of individuals, or types of individuals, was studied by Antipoff (112), Brown (117), Hull (147), Kelly (154, 155), Robinson (188), Wallin (209), and Woodrow (211). The results were somewhat contradictory. Hull found that the distribution of measures of variability for a given individual approximates the normal frequency curve, although individuals differ greatly with respect to the range of the variabilities. Brown found about equal variation in trait measures for bright and dull persons. Wallin found that the normal were more variable but in Woodrow's study the normal group showed less variability.

Measurement of Special Traits

Because of differences in the purposes and methods of the experimenters and because traits were defined differently by various workers, it is difficult to compare trait measures and indeed to identify them accurately. The field of trait measurement overlaps that of achievement testing and, to some extent, that of general mental measurement. However, collections of trait tests were brought together and presented by Bronner (116), Hull (146), Paterson (186), and Wells (210). Wells was concerned chiefly with measures of ability appropriate for clinical use regardless of their implications

concerning the nature of traits. Bronner listed a number of separate tests and test series and cited references dealing with them. Hull outlined and interpreted the needs in aptitude testing and summarized the work already done in that field. Paterson discussed the theoretical and practical implications of measurement of special traits.

Musical abilities were analyzed by Seashore (194). Careful diagnostic work was also done by Kwalwasser (167). Fracker and Howard (134) reported a low relationship between intelligence and musical talent among college students. McCarthy (174) confirmed Seashore's findings as to the accuracy of the Seashore Tests in the measurement of musical ability.

Meier (178, 179, 180) reviewed the literature on artistic talent and reported original work in the measurement of artistic ability. About the same time, Goodenough (139) studied children's drawings as an index of maturity. More recently, an excellent series of tests of artistic ability was reported by Lewerenz (168, 169). He found little relation between test scores alone and ability as measured by art schools.

The eidetic phenomenon¹ has attracted much attention since Jaensch's (149, 150, 151, 152) first work in the field. In addition to his studies, work was done by Cramaussel (125), Garfunkel (136), Gatte and Vacino (137), Gengerelli (138), Hansen (140), Joesten (153), Kiesow (159, 160, 161), Klüver (162, 163, 164), and Zeman (212).

Comparative and genetic studies of children's development by means of standardized tests, or by group tests originated by the author, have been common. Several of these, concerned chiefly with establishing central tendencies, appeared in Japan. The investigations of Kido (158), Kuwata (166), and Narasaki (184) showed this trend.

Vocabulary was used as a measure of intelligence or learning ability, by Conrad (123), Cuff (126), Dolch (130), Schneck (192), and Shambaugh (195). Their results did not give a final answer to the question as to the relation between verbal ability and general intelligence.

Beck (113, 114), Kovarsky (165), and Loosli (172) reported the technic employed by the Rorschach Profile Test and analyzed the theory underlying the test. Rossolimo (190) developed another profile test designed to measure intelligence and other personality traits. Both tests have been widely used.

Intelligence and achievement tests have been utilized in studying the tests themselves and in determining the effects of learning. DeWeerd (128) and Slocombe (197) analyzed, under controlled conditions, the effect of different amounts of learning on test scores. They concluded (1) that there was

¹ Eidetic images are subjective visual phenomena resembling after-images. An eidetic individual is not only able to *imagine* an absent object but also to *see* it, either when he closes his eyes or when he looks at some surface which serves as a convenient background. Eidetic images differ from after-images in that an object may be seen after a considerable period of time has elapsed since its removal—perhaps several days. The individual who possesses eidetic images is in general a normal and healthy person.

little effect from similar learning, and (2) that the best way to eliminate uneven effects of previous direct learning on test scores was to give adequate fore-exercises, or to repeat the examination.

The relation of motor ability to general intelligence was studied by Piaget (187). He reached no statistically verifiable conclusions. Hindman (143) reported that, in a certain university, those with better motor skill made slightly lower scores. Results from a general series of motor tests in relation to sensory traits and intelligence were reported by Sommerville (198). The test series developed by Oseretzky (185) was also reported by Kernal (157). Miles (181) developed the Pursuimeter, a motor test that has been widely used as a measure of skill in simple coordination. Brace (115), Garfiel (135), Schultz (193), Shevalev (196), and Walker and Weedon (208) were all concerned with developing tests of motor skill. Likhacheva (171) studied motor ability in children from the point of view of physiology.

Association as a mental phenomenon has been studied by means of association tests of different types. Malmud (177) expressed a preference for controlled association tests because of their greater accuracy. Others preferred the free association tests. Rosanoff (189) published a reprint of the Kent-Rosanoff Test. Cason (120), Conrad (123), and McFadden (175) utilized free association tests in their analyses of adjustments and psychological types.

Immediate memory was studied by Fischler and Ullert (132) and by Dodge (129).

Cleeton (121) summarized the literature dealing with experimental work in the field of reasoning. After that summary was published, important work was done by Alpert (110), Burt (118), Hicks (142), Huang (144), Lorimer (173), Maier (176), Moore (182), Piaget (187), and Thurstone (204, 206). Erismann (131) made a genetic study of reasoning, using reasoning tests. Isaacs (148) refuted Piaget's assumptions as to the growth of reason in the child.

CHAPTER III

The Nature and Extent of Individual Mental Differences

THE nature and extent of individual differences are dependent in part upon the growth of intelligence, upon the age of mental maturity, and upon the distribution of intelligence in the general population. These topics, together with the effects of sex, race, and social status upon individual differences, will be discussed in this chapter.

Growth of Intelligence and Adult Mental Age

There has been a great amount of controversy as to the exact age at which mental growth ceases. This problem first became troublesome when Terman (257), in computing the I. Q., found it necessary to select some chronological age for the adult level beyond which no increase in mental growth was expected. Upon the basis of his adult samples, he selected sixteen years as the point of adult maturity. More complete samples of the adult population as disclosed by the testing program of the national army during the World War showed that adult white drafted soldiers averaged no better in general mental level than did school children between the ages of thirteen and fourteen years chronologically. Acute differences of opinion arose over whether or not the army draft represented an adequate adult sample.

This problem is not simple. Discussions of the various factors which contribute to its complexity were presented in texts by Dearborn (223), Freeman (225), and Thorndike (259). Dearborn showed that the content of intelligence tests is so similar to that of scholastic tests that adults removed from the immediate school environment temporarily forget factual material. Hence adults appear to be no more intelligent than pupils in the sixth grade. Freeman presented and discussed the data available prior to the publication of his text in 1926. He also presented theoretical hypotheses as to the relation between level of intelligence and age of maturity, as follows: (1) that all individuals may develop and reach maturity at about the same age; (2) that individuals with high I. Q.'s may reach maturity sooner than those with the lower ones; and (3) that the brighter children may reach maturity at a later time than those with lower I. Q.'s. Data on the growth curves of the mentally subnormal are becoming available in clinics in rapidly increasing amounts. The phenomenon of the falling I. Q. with increasing chronological age among subnormal children has been recognized for some time. Using data from the files of the Detroit Psychological Clinic, the writer computed I. Q.'s for several hundred subnormal children and compared them with earlier

I. Q.'s before the chronological age of sixteen years was reached. In dividing mental age by sixteen the I. Q. tended to fall; in dividing by fourteen there was a slight rise in the I. Q. At the age of approximately fourteen years and four months, the I. Q.'s tended to remain constant. Fewer data are available relating to average or superior children. For subnormals, the evidence indicates that maturity is reached soon after the age of fourteen years. Thurstone and Ackerson (261) reported on the Binet M. A. of 4,208 white children with chronological ages from three to seventeen years. The mental curve had a positive arc to the age of ten years, then an inflection point between nine and twelve years which become asymptotic to the adult level. They concluded that the adult level was reached earlier by bright pupils than by dull ones.

Thurstone (260) reported on the fallacies of using the mental age concept at the adult level and proposed the use of percentile scores. These, he believed, could be compared with greater accuracy and with them more meaningful standards could be developed.

Thorndike (259) discussed the difficulty of differentiating between the materials in intelligence tests which measure maturity and those which measure training. He pointed out that individuals may cease to improve in altitude upon the CAVD Test and still continue to improve in such things as business, child management, and social arrangement. He suggested that the units of measurement used in intelligence tests may readily lead to faulty conclusions. He pointed out that the methods of partial and multiple correlation must eventually be employed with significant data to differentiate the two factors, maturity and training.

Individual Differences

Pioneer work in the field of individual differences was done by Galton, Cattell (218), and Pearson. The first systematic presentations were made by Stern (253) in 1900 and by Thorndike (258) in 1903. A tremendous amount of literature has appeared since that time. An increasing recognition of the importance of individual differences is one of the distinguishing characteristics of educational theory and practice during the past twenty-five years. The determination of individual differences as accurately as possible and the guidance of individuals into the vocations for which they are best fitted have come to be regarded as important educational problems.

Early investigations showed that the distribution of differences in mental traits covers an enormous range. A marked looseness in the interrelationships between traits was disclosed. These first studies also dealt with the effects of race, sex, family, maturity, and training in producing differences. In more recent years attention has been centered on the improvement of tests and measurements, on refinements in statistical methods of determining differences, and on more rigorous control of the factors of selection

and training in the groups tested. A decidedly more critical attitude toward the principles and technics of mental measurement has arisen.

A widely accepted doctrine in individual psychology is that the distribution of individual differences in all mental traits conforms approximately to the normal probability curve. Boring (216, 217) critically and vigorously attacked this doctrine and expressed skepticism as to the importance of the discovery of the applicability of the normal distribution to mental traits. He contended that strictly unselected groups were never available; that differences might be due to inequalities of training, to inequalities in units of measurement at different ranges and levels, and to errors in measurement. Kelley (238) replied to Boring at length and suggested four units in mental measurement: (1) the sense difference unit; (2) the variability in performance unit; (3) the group variability unit; and (4) the unit resulting in the simplest picture of interrelationships. Thorndike (259) recognized the uncritical character of the *a priori* assumption of a normal distribution, but realized also the great importance of the problem for present and future practice in mental measurement. He demonstrated that the distribution of general intelligence for children in the sixth to the twelfth grades approximated the normal curve when three precautions were observed; namely, when equal units of measurement were employed, when inequalities in training and the influence of selection were eliminated, and when errors in measurement were reduced to the minimum.

Sex differences—The belief prevails in popular opinion that sex differences are highly significant in psychological measurement. Objective data available to date do not confirm this hypothesis. Freeman (225) summarized the earlier studies and reached this conclusion in substance. Whipple (264, 265) reported two studies of sex differences in general intelligence. Among eleven-year-old children in the elementary school, girls surpassed boys by approximately seven months in mental age according to their scores on the National Intelligence Test. He also reported that at the high-school level, on Army Alpha, boys were slightly superior to girls. Winsor (266) reviewed a bibliography of forty-nine titles on sex differences and concluded that the two sexes are equally variable whenever significant numbers are tested at any given age. In the opinion of Book and Meadows (215) the superiority of girls over boys from ages nine to sixteen is probably related to the recognized accelerated physical development of girls over the rate for boys during the period of adolescence. Investigations of sex differences with respect to mirror drawing, as reported by Clinton (219), showed that boys excelled girls up to thirteen years of age and that after that point the girls excelled the boys. Evidence from many sources has shown that in general or special mental ability sex differences are usually too insignificant to warrant the establishment of separate sex norms.

Race differences—In recent years race differences have also been widely investigated by means of psychological tests. More than fifty articles in periodical journals reported research studies in this field in the past four years alone. In the opinion of the committee many of these studies do not adequately sample the racial groups. It has often been assumed that immigrant racial groups are definitely inferior to the native stock. The chief reasons for this belief may be easily identified. In the first place, language difficulties have set up barriers and often caused these groups to do poorly on verbal tests. Second, although our customs and laws are different from theirs and are not easily understood by immigrants, those who do not readily conform are judged to be inferior. Finally, an immigrant population may be an inferior and inadequate sample of its own ancestral stock because of social and economic selection. In most of the investigations thus far reported psychological test scores for the various racial groups have been compared with norms for the native population. Murdoch (245) used the Pressey Group Intelligence Test with twelve-year-old children in New York and Honolulu. In New York, where native born white children excelled, Jewish and gentile groups ranked about equally high, negroes were next in order, and Italians were lowest. In Honolulu, north Europeans and Americans were highest; these were followed by Chinese, American-Hawaiians, Japanese, Koreans, Chinese-Hawaiians, Portuguese, Hawaiians, Porto Ricans, and Filipinos. Hybrids fell between the two parent stocks. Porteus and others (248) in a similar study found essentially the same gradations of intelligence in these racial groups. Goodenough (229) tested 2,457 young children with the Goodenough Intelligence Test for Young Children which is independent of language. Her work was performed in southern and western states. In order to balance social and economic status as nearly as possible she did not include children from superior American homes. Nevertheless she found that the negroes and south European stocks were distinctly inferior.

Several investigations of the intelligence of negro groups have been made. These tend to show inferiority to American whites in practically all instances. On the contrary, Sunne (256) concluded, after some experimental testing, that there were no race differences between whites and negroes which could not be accounted for through differences in educational opportunities, and Petersen and others (247) reported that negro children excelled whites in special tests of retention and memory. Garth and others (228) and Graham (232) reported minor differences in young children, but differences increased markedly with age in favor of the whites. Strachan (254), using the Stanford-Binet on kindergarten and primary children in Kansas City, found negro inferiority among these younger pupils as well as among the older ones. Price (249) and Graham (231) reported deficiencies of ten points on the Otis Self-Administering Test for negro college freshmen. Sixty-three percent of the whites surpassed the negro median in intelligence.

Reports on Indian children tend to show an inferiority on the part of this racial group. Jamieson and Sandiford (235) found median I. Q.'s on southern Ontario Indians as follows: National Intelligence Tests, 80; Pintner-Cunningham, 78; Pintner Non-Language, and Pintner-Paterson, 97. Blackwood (214) concluded that Indian mental inferiority is partly due to lack of knowledge of the civilized conditions which mental tests presuppose. Travel seems to produce and stimulate culture among Indians, for Garth (226) discovered that 67.3 percent of the sedentary Indian groups fell below the median of the nomadic groups. Klineberg (240) found that the Indians were relatively better on performance tests than on verbal tests, which suggests language difficulty and lack of educational opportunity. Mixed-blooded Indians, as reported by Garth (227), tend to be slightly higher in intelligence when the white factor is more predominant.

A study of Oriental races reported by Wen (263), contains an interesting résumé of a testing program carried out with Chinese children. He also summarized the work of eight American psychologists. Wen found no marked evidence of racial inferiority or superiority. Surveys of Japanese children by Darsie (221) indicated weakness in those mental processes which involve memory and abstract thinking in the English language, but superiority to American children in equivalent tests with non-verbal material.

Social and economic status—Considerable evidence was derived from the army tests indicating a high correlation between intelligence and social and economic status. More complete analysis of the data, as reported by Lehman and Stoke (241), showed that fully one-half of the A and B caliber men were drawn from the non-white-collar occupations. Two studies of the intelligence of school children and the occupational status of their parents were reported by Collins (220) and Goodenough (230). The traditional excellence of the professional groups was reflected in the scores of their children on the mental tests, but there was considerable overlapping of the two distributions. This precludes the idea of a complete class separation. Van Dael (262) reported similar findings from a study in the Netherlands, as did Kirahara (239) from a study of elementary-school children in Japan. Studies based on large numbers of cases including the entire population of communities are quite lacking.

Shimberg (251) gave two standardized tests to urban and rural children, and although the rural children made a poorer showing, the difference was attributed in part to the fact that the test material was more favorable to city than to rural children. Hirsch (234) measured 1,845 school children in the Kentucky mountain districts. He found an average I. Q. in the high 70's and a negative correlation between I. Q. and C. A. The latter suggested the presence of poor environmental factors operating in the case of older children. Hatcher (233) reported that fewer than one-fourth of the mountain children in a typical mountain school in Virginia were of normal in-

telligence. Russell (250) reported a study of gifted children in rural England showing that fully 50 percent of the group were recruited from the superior social classes. He also reported slightly higher mental levels when the parents did not both come from the same communities. Marsden (243) found fewer bright children, and more average children, and about the same proportion of slow children in remote country schools where many children were suffering from lack of more adequate educational facilities as in the total group in two complete county surveys.

The *Twenty-seventh Yearbook* of the National Society for the Study of Education (246) dealing with the influence of nature and nurture presents conflicting evidence as to the influence of nurture. In this yearbook Rogers reported no gain in the I. Q. of sixty-four girls taken from poor economic levels and placed in a well-managed institution. On the other hand, Freeman reported an increase of ten points in the average I. Q. of children placed in foster homes. Orphan children were found by Davis (222) to have median I. Q.'s of about 85. Jones and Carr-Saunders (236) reported that English orphan children of low status seem to improve mentally, and superior children to deteriorate, when placed in orphanages.

Moss and Hunt (244) analyzed seven thousand scores on the Washington Social Intelligence Test. They discovered that business executives make higher ratings than all others, and that women show higher ability in matters of tact and recognition of behavior than men. Strang (255) reported on the use of the same test. She believed that abstract intelligence is measured largely by this test, and that otherwise, the test measures only a small residue of social intelligence.

A study by Lentz (242) on the size of family and I. Q. showed a lower median I. Q. for the larger families. There was but one exception, and the discrepancy in that case was not statistically significant. From the study of 6,790 children from 2,712 families Steckel (252) reported a small but consistent superiority in the intelligence of younger children over that of older children in the same families. Arthur (213) found a similar trend among immigrant children to the United States with a significant statistical difference of six points in I. Q. In contrast to these findings are those of Jones and Hsiao (237) who found no significant correlation between intelligence and birth order in 614 pairs of siblings. If careful records are maintained for a few years, very significant data will be available from many of the mental clinics on the intelligence of parents and their children. Many children will be studied whose parents were also examined in their childhood. These studies will take into account such factors as social and economic status and will throw important light upon many of our present problems.

Summary

The age at which mental maturity is reached is still an unsolved problem but the evidence points to earlier cessation of growth than was at first believed. Distributions of general intelligence as well as most special abilities seem to follow the normal frequency curve. Sex differences have not proved to be important enough to warrant the establishment of separate norms. Race differences have not been accurately determined because of the influence of special selective factors and the inability of investigators to equate completely the different cultural patterns. Negro and Indian groups seem to be inferior to native white stocks according to present tools of measurement. Studies of social and economic groups show a great overlapping in intelligence and a fairly high positive correlation between educational and cultural opportunities and intelligence.

CHAPTER IV

The Construction and Statistical Interpretation of Psychological Tests

INVESTIGATIONS into the nature and function of psychological tests have been greatly facilitated and advanced by the discovery of sound principles of test construction, by the use of better methods in the selection of test items, and by improvements in the various kinds of statistical interpretation. A few comments on these topics are presented here with their particular applications to psychological tests.

Selection of Test Items

Terman (301) gave one of the earliest detailed descriptions of the construction and scaling of psychological tests in reporting the procedure used in standardizing the Stanford Revision of the Binet Test. More recently Freeman (277) and Thorndike (302) brought together the best in current theory and practice. Among other questions, Freeman (278) analyzed power and speed in tests; and pointed out that if a test is given with time limits and again without, and that if a high correlation is found between the two results, the test is primarily one of power. Kuhlmann (286) discovered that if test items were too easy, the problem of proper motivation entered in, disturbing the optimum measurement of intelligence. When the items are too easy, test results indicate chiefly speed of automatic processes. Symonds (299) presented six criteria with respect to the proper difficulty of test items:

- (1) The items with which one can measure the ability of an individual most accurately are the items that he can do with 50 percent accuracy.

- (2) The test which measures an individual most accurately is one made of items, all of which the individual can solve with 50 percent accuracy.

- (3) The best item for measuring two individuals is the item lying in difficulty midway between the difficulty of the two items which can be answered with 50 percent correctness by each of the individuals.

- (4) The best test for measuring two individuals is one composed of items as in (3).

- (5) The best test for measuring a typical school grade or class is a test in which all of the items have a difficulty such that they can be answered with 50 percent accuracy by the average individual of the group.

- (6) The best test designed to measure several consecutive grades or classes is one in which the items have been so selected that they range evenly in difficulty from the level of difficulty which can be done with 50 percent accuracy by the average member of the lowest group to be tested, to the level of the difficulty which can be done with 50 percent accuracy by the average member of the highest group to be tested.

Clark (269) proposed a plan for evaluating an individual test item, not only on the basis of its difficulty, but also in terms of whether it is correctly answered by a greater proportion of good students or poor stu-

dents. Obviously a test item lacks validity if it is correctly answered by as many of those who rank low as of those who rank high with respect to the ability which it purports to measure.

Test Construction

Among the most common types of test items are the completion exercise, multiple-choice exercise, and the true-false question. In a comparison of true-false and completion tests by Shulson and Crawford (297), the latter was as valid as the former on material which was relatively unfamiliar. The completion test lacked objectivity, but the true-false test involved guessing. Hanumantha and Gopalaswami (281) reported that in retesting adults with a four-response multiple-choice group test, change was made from wrong answers to right ones about twice as often as the opposite condition, whereas children change with equal readiness in both directions. Fritz (279) showed that when very difficult material was presented 62 percent of the items were marked true and 38 percent false, although in reality half the items were true and half were false. Lehman (289) showed that on a retest superior students make fewer reversals and better scores on true-false tests, whereas poorer students make more reversals and lower scores. Mathews (290, 291) showed that if alternate answers such as "more" or "less" are printed one above another there is a tendency to select the upper of the two answers. Likewise, he found that if two answers such as "yes-no" are arranged in the order shown here, there is a 3.2 percent greater tendency to mark the left answer than the one at the right. He also found (1) that changing answers on true-false tests raised scores in 63 percent of the cases, lowered them in 34 percent, and on 3 percent had no effect; and (2) that changes in multiple responses raised scores for 53 percent, lowered them for 21 percent, and produced no change in 26 percent of the cases. Arnold (268) found that unless a false statement was very ridiculous, there was a stronger tendency to mark false statements true than to mark true statements false.

Scores and Norms

One of the most concrete and complete discussions of scores and norms was offered by Freeman (277). Without doubt variations in types of material, time limits, difficulty of items, and types of response materially affect norms; yet from norms conclusions are sometimes drawn as to the comparative intelligence of different age, race, and social groups.

Pintner (294) reported that the students in a graduate class assigned scores ranging from 34 to 85 to the group intelligence booklet of one pupil, exclusive of two freak scores of 3 and 18. Training reduced this range from 58 to 90 on a second similar booklet. The average difference from the true score was reduced from 9 points to 3 points through training. Dearborn and

Smith (273) rescored more than five hundred Dearborn tests and found many disturbing factors causing particularly persistent underscoring. Whether to weight items of varying degrees of difficulty or to assign equal values to all items regardless of difficulty is a problem which is still open to further investigation. Accidental success on a few of the more difficult items by relatively poor subjects tends to neutralize the beneficial effects of weighting the more difficult items. Kuhlmann (287) proposed an age norm for each trial of each test instead of the customary summation of total scores on the entire test battery. Thurstone (305) criticized Thorndike's assumption that standard deviations by grades were equal and showed that by projecting the elements of the test upon a true scale the wide gaps occurring in the upper grades may be explained. Ellis (275) suggested that the effect of speed on results obtained with timed tests may be measured by giving an alternate form of equal difficulty as an untimed test and computing an index of speed from the difference in the two scores.

Wallin (306) reported on the standardization of the items of the Stanford-Binet Test, ages eight and nine, using the scores of 1,382 children. He found no significant sex differences. He reported that the eight-year tests discriminated between normal children of seven and nine years, but that the nine-year tests only partially discriminated between ages eight and nine. In the nine-year tests the life experiences of the older and duller groups seemed to compensate for brightness. He concluded that the tests on any one age level were not equally difficult for any one "brightness" classification.

Abelson (267) reported on the improvement of intelligence testing. He calculated college success criterion scores by the T Scale technic for the Thorndike, Roback, Brown, and Thurstone Tests. The results were less promising than was hoped on account of the relatively low validity. A useful bibliography of forty-five titles is appended to this study. Thurstone (303) proposed that the absolute zero in intelligence measurement be defined as a certain distance below the mean performance of any age group in terms of its own standard deviation. He contended that with uniform testing conditions the relative variability of absolute test intelligence of different age groups is constant. Thurstone (304) also proposed a method for combining a large number of scores secured on various tests into a single composite score. The principle of scoring involved is that a valid score on a series of tests has above it as many successes as there are failures below it. Cole (270) constructed a conversion scale for comparing scores on three secondary-school intelligence tests using the scores of 6,550 pupils from fourteen preparatory schools and employing Holzinger's (283) transmutation formula.

Test Reliability

The reliability of psychological tests has been quite extensively investigated in the past few years with the correlation technic. Rugg and Colloton (296) reported on earlier studies, and more recent studies have been made by Hildreth, Lincoln, Randall, and Slocombe. Pintner (295) reported on the standardization of the Pintner-Cunningham Primary Test with norms based on 29,533 children. The reliability coefficients ranged from .72 to .85. Cowdery (271) reported the administration of the Thorndike Intelligence Examination with repeated tests at intervals ranging from a few days to one, two, and three years. He found a declining reliability coefficient, from .80 to .648, with the longer time intervals between tests. He interpreted his results as due to changes in attitude and to the varied educational experiences of the subjects in the interim. Kornhauser (285) and Lanier (288) presented further studies of the reliability of tests. Symonds (300) discovered the following factors which make for greater reliability in a test: (1) many test items, (2) a long time limit, (3) a narrow range of difficulty, (4) few interdependent items, (5) little operation of chance, (6) correct scoring, and (7) objective scoring. Edgerton and Toops (274) derived tables for predicting validity and reliability coefficients of a test when it is lengthened. Holzinger (283) evaluated the well-known Spearman-Brown formula for predicting the reliability of lengthened tests and also presented a formula for predicting their validity.

Constancy of the I. Q.

Studies of test reliability helped to create and intensify interest in the question: Does the I. Q. remain constant? Investigators who were making repeated measurements in order to establish the reliability of a particular test were confronted with this challenging problem. Consequently, many studies were launched dealing directly with the constancy of the I. Q.

Matthew and Luckey, in the *Twenty-seventh Yearbook* of the National Society for the Study of Education, (292) reported on thirty-eight children whose I. Q.'s shifted more than five points on retests. In all but seven cases there appeared to be some unusual factor in the child's make-up, or in the conditions surrounding the tests, which conceivably could result in the observed instability of the intelligence quotient. Most of the studies which have been reported show correlations of approximately .90 to .95 between the scores on repeated tests. Dearborn and Long (272) compared I. Q.'s at different age levels; and concluded that if the I. Q. is constant, then the relative ability of the child is not constant but varies according to some unknown law with which the Binet Test happens to be in conformity. Foran (276) offered a supplementary review of the constancy of the intelligence quotient involving thirty recent studies. He concluded

that the I. Q.'s of the feeble-minded were more constant than were those of normal children, and that they were more constant for individuals sixteen years of age than for those below the age of sixteen at the time of the first test.

Correlations

The use of correlations in determining reliability of tests has already been noted. Correlation is also an important tool in other phases of psychological tests such as evaluating special abilities and disabilities, or studying group mental measures. Garrett (280) offered a simple yet comprehensive discussion of the various correlation technics. Hull (284) emphasized certain facts concerning the uses of correlations in prediction. In his opinion, correlations lower than .5 are of no *predictive* value; between .5 and .6 they are possibly useful; between .6 and .7 they are of genuine but limited value; between .7 and .8 they are of decided value but rarely found; and correlations above .8 are not obtained by present methods.

Partial and multiple correlation will undoubtedly prove extremely useful in studying the effects of various factors other than nature which contribute to scores on psychological tests, but studies in this field are still meager on account of the scarcity of numerical measures for the non-intellectual factors which operate on test results. These correlation technics have been called into use somewhat more extensively since the publication of Spearman's (298) treatise on the two-factor theory of intelligence. Studies by Pearson and Moul (293) and Holzinger (282) illustrate this trend.

Summary

Test items should be selected according to definite criteria of difficulty and validity. Chance affects test results to a considerable degree when true-false test items are employed and to a lesser but appreciable extent when multiple-choice exercises are used. Interpretations of psychological tests should be made, not only on the basis of statistical analyses, but also with due consideration for the influence of test items on the statistical interpretations themselves. The uses of statistics and complex correlations will be enhanced when tests are devised to measure more varied phases of intelligence and qualities other than those measured by existing tests.

CHAPTER V

The General Uses of Psychological Tests

THE VARIETY of purposes for which psychological tests are used may be classified under the heads of either diagnosis or prediction. Even their use for purposes of diagnosis may be thought of as a phase of prediction. Diagnosis is of no significance educationally unless it is followed by some sort of educational procedure based upon the predictive value of the facts established. Appraisal and measurement of intellectual status is a necessary preliminary to the inauguration of any instructional program, knowledge of status *per se* being of interest chiefly to sociologists and others concerned with various aspects of social welfare. Consequently, this chapter places major emphasis on the various predictive uses of intelligence tests. The discussion begins with a statement of specific uses which the tests may have. Studies relating to their use in classification, in predicting success in school subjects at the various school levels, and in predicting teaching success are then cited.

Uses Made of Test Results

McClure (328) studied, by means of a questionnaire, the prevalence of psychological services in certain large city public-school systems and listed the various ways in which tests were reported to be used in those cities. Most important of all, according to this report, was the use of psychological tests as a device for sectioning classes or for classifying pupils into homogeneous groups for instructional purposes. Other uses listed were determination of low mentality for purposes of exclusion from school; vocational guidance; recommendation for work permits; adjustment of problem children; selection of pupils for special classes; high-school graduation; eligibility of non-resident pupils for admission to high school; classification of beginners; as an element in promotion standards; appraisal of the curriculum; evaluating methods of teaching; objectifying standards of achievement; recommendation of candidates for scholarships; skipping and accelerating pupils; promotion of doubtful cases; psychiatric and neurological observation; and, as part of the diagnosis of juvenile court cases and cases referred to social agencies. This study does not specify in detail the manner in which tests are used for these various purposes. There is obviously much overlapping in the functions described. These uses, so far as they represent actual and possible uses of tests, may be taken as representative of practice where psychological testing is carried on.

Use of Tests in Classification

The use of psychological tests as a basis for sectioning and grouping of normal pupils was presented by Rankin (338: 205-10) in an earlier number of the *Review*. The conclusion reached in that analysis concerning the practice of grouping was that there is little positive evidence of its value in terms of better results achieved. This condition is held to be due to the probability that little is done about modification of curricula or methods of teaching after grouping has been brought about. This does not necessarily reflect upon the theoretical desirability of homogeneous grouping, or upon the validity of psychological tests as a sole or contributing device in the organization of such groups. Many of the studies bearing upon this question were reviewed in the earlier report, but one in particular merits further attention. Keliher (325) attacked the whole practice of grouping on the grounds that it did not square with an educational theory which conceived education as growth and which should take the whole child into account. So far as tests are concerned, her point was that existing tests do not measure all the abilities which it is necessary to consider in achieving any degree of homogeneity which may be used as a sound basis for educational procedures affecting the whole personality of the child. She claimed, furthermore, that individuals are so specific in their abilities that it is impossible to achieve such homogeneity.

Symonds (342) answered the argument insofar as the use of intelligence tests was concerned. His defense, however, was based largely upon the assumption that the existing school curricula conceived in terms of static and extrinsic subjectmatter categories is necessarily the norm against which classification devices must be measured. Keliher based her argument against grouping largely upon a denial of this assumption.

In summarizing the studies having to do with bases of grouping, Rankin (338: 210) in the earlier *Review* said:

The available evidence at the present time suggests that teacher judgment and results of intelligence tests are of approximately equal importance for ability grouping, and that both should be used in the classification of pupils into homogeneous groups. Other factors should undoubtedly be utilized also, and, indeed, different ones are used in various places with a degree of success, but none of them is in general use. However, where it is possible to group separately in different subjects it is agreed that educational tests are of very great value.

Psychological Tests as a Predictive Device

The second major administrative use of psychological tests is for purposes of prediction. Although, as has been pointed out, the use of tests as a basis for classification is essentially a phase of prediction, the difference in the two uses lies largely in the technics employed. Those who have been interested chiefly in the predictive value of tests have usually relied upon some form of regression equation, taking account of whatever variables

seemed to be significant. Much attention has been given to the possible predictive value of simple correlations between intelligence test scores and measures of ability in the function for which a predictive device was desired. For the most part, correlations between intelligence test ratings and ability in other functions, such as scholastic success in high school or college, success as teachers, persistence in college, and the like, are low and of relatively little statistical significance. Most writers attribute the low correlations largely to the unreliability of the psychological tests, to the absence of adequate and valid measures of success in other functions, or to the nature and scope of abilities within the population measured.

Many investigators have calculated coefficients of correlation between academic success in school or college and various measures of intellectual status. Pintner (333) listed many tables of such correlations, both for high-school and college students, reported by various authors. Most of these range between .40 and .60, but the number falling below .40 is greater than the number falling above .60. Many studies of this type were doubtless launched because of the desire of administrative officials to find reliable measures which might be used in connection with entrance requirements or as a guide in connection with the subsequent elimination of students who do not prove able to get along. Thus, Crawford (314: 125) said of college students:

Reliable estimates of individual students' fitness for college work are obviously important in determining whether or not they should be admitted. The whole array of school credits, entrance examinations, psychological and other tests, evidences of good character, personal references, ratings, etc., is concerned with two questions: (1) Can this candidate probably maintain a satisfactory record in his college studies? (2) If so, is he, in other respects also, the sort of individual whom we want in our student body?

This view doubtless underlies much of the investigation that has been carried on with respect to high-school students as well. But in their case, there is less significance in the question of initial estimate before admission, for it is coming to be generally conceded that the high school should be available for all who choose to come. Therefore, at the high-school level, psychological tests are of value, for the most part, in guidance after admission. The slight attention which has been given to the prediction of high-school success is doubtless due to the more universal character of the high school, its definite place in the public-school system, and the consequent greater attempt to develop educational activities well adapted to whatever quality of mentality is found therein. Admission to high school seems well enough restricted, so far as mentality is concerned, by the necessity of passing elementary or junior high-school examinations as a pre-requisite to promotion. This democratic attitude toward educational opportunity has not become so general among those concerned with college problems. Hence, much thought is still given to the possibility of using psychological tests as barriers for the elimination of the undesirable.

A number of attempts to predict high-school achievement have been made. Ross (339, 340) studied the possibility of predicting success in high-school subjects on the basis of elementary-school records, but intelligence tests were not used as part of the data. Proctor (336) used psychological test results, as well as other evidences of ability, in the guidance of students in their choice of studies. Todd (343) also tried to discover whether a certain group test of mental ability had value for prediction of success in particular high-school subjects. She found that the correlation between the entire battery and various subjects ranged from .16 for commercial subjects to .33 for English and mathematics, and that individual tests of the battery were in no case of greater predictive value than the entire test. Tozer (345) analyzed results of tests of high-school students in grades nine to twelve and calculated regression formulae. Ratings on intelligence tests and on certain study habits seemed to have greatest predictive value when combined. By means of the formula he was able to predict the marks in 77.72 percent of the cases for ninth- and tenth-grade students and in 83.26 percent of the cases for eleventh- and twelfth-grade students. He concluded that accurate intelligence ratings would be of great aid to a counsellor in high-school guidance work.

These studies bring out the point that psychological test results alone are not an adequate basis for prediction, even in connection with activities which might be thought most closely related to those mental functions measured by the existing tests.

Prediction of Academic Success in College

Many studies of prediction have had to do with college students. The investigators have used high-school marks, results of intelligence tests, entrance examinations, and early evidence of success in the college itself, in devising predictive formulae. Some of these studies have been very detailed and exhaustive; for example, those of Odell (332) and Edgerton and Toops (318). Odell's study was based upon the records of high-school students in Illinois and their continuation in various colleges in the state. Simple prediction of college marks from high-school marks and intelligence test scores gave correlation coefficients of .20 to .50. Prediction of college marks in the upper three years based upon various combinations of high-school and freshman data gave correlations only slightly higher. Odell concluded that there is a definite relation between these factors which at least enables one to raise the selection of college students above the guessing point, perhaps to the degree that the guess element can be reduced to about one-half. Edgerton and Toops (318) made a similar study of university students and found low correlations between percentile ranks in intelligence test scores and persistence in college.

Other studies have been briefer and have given results similar to the more detailed and exhaustive ones. Gerberich and Stoddard (322) were able to obtain a correlation of .50 to .54 between their test battery and first semester college marks of a group of selected students. The group was composed of students who ranked in the upper 10 percent in intelligence among the Iowa high-school seniors tested in their survey. Alderman (307) concluded from examination of the records of failing university freshmen that there was a direct and significant relation between intelligence and subsequent record, but he did not attempt to correlate the measures. Cleeton (312) found that the Thorndike Intelligence and Iowa Content Examinations were of about equal value in predicting success in a college pre-engineering course, and that prediction could be raised to a coefficient of about .60 to .65 by combining the two. Crawford (314) found that scholastic aptitude tests alone correlated about .40 for Plan A and .48 for Plan B students at Yale. When the College Entrance Board Examinations were combined with school records, scholastic aptitude tests, and age of entrance, a formula of prediction was devised which gave a coefficient of .7358 for Plan A and .68 for Plan B students. Potthoff (335) pointed out the difficulty of finding bases that are adequate for prediction in all cases, but he held, on the basis of correlations obtained between two-year course records and intelligence, and between high-school average marks and first-year college marks, that retention and dismissal at the end of the first quarter might be placed on a much more adequate basis. Dilley (316) found that psychological tests were fairly accurate in identifying a group of students who will not be found in the higher scholarship ranks in college, but that many in the lower ranks on intelligence tests do make satisfactory records in college.

Davidson and MacPhail (315) found correlations of .50 to .55 between psychological test scores and college marks. Freshmen in the lowest tenth, according to test scores, received seven or eight times as many failing course marks as those in the highest tenth. Students in the lowest tenth had about an even chance of remaining more than one year and about one chance in three of remaining till the end of their senior year. Two-fifths of the students who were refused registration during or at the end of the freshman year because of poor scholarship came from the lowest tenth. Rank in preparatory school senior class, weighted according to size of school, and test scores from the preparatory school combined with individual test scores, correlated .70 with freshman marks. Freeman (321) said that the chances of a student's remaining until graduation range from 48.7 per hundred for students in the lowest decile of the psychological examination to 87.8 per hundred for those in the highest decile. He concluded that mental tests can be used only as supplementary information in attempting to predict academic survival.

Gray (323) found young college students who were admitted under the age of sixteen to be definitely superior in intelligence to their own and other

college bodies generally and, as a group, to get along better than a control group made up of a random selection of college students who were on the average two years older. Kornhauser (326) made studies of student records extending over several years, but all correlations between intelligence, high-school record, or other measures and college success were low, ranging from .45 to .60. Like Dilley, he found that psychological tests were chiefly valuable as predictive devices within the low ranges of the abilities measured. Toll (344) reported results of several different tests used at Amherst, but found no test that picked out a lowest 4 or 5 percent for whom one could safely predict college failure, either for the freshman year or the entire course.

Many other similar studies of college and high-school students have been reported, such as those of Brigham (308), Condit (313), Maddocks (329), Nelson and Denny (330), and O'Brien (331). All are of substantially the same import. Psychological tests are valuable aids in prediction, but they must be combined with other measures to obtain any degree of reliability. Even then such measures can be used safely only for the extreme cases. Frasier and Heilman (320) are perhaps more enthusiastic in their view of the predictive value of psychological tests than most other writers. They commend them heartily.

Prediction of Teaching Success

Psychological tests have been used frequently in attempting to predict the success of normal-school and teachers-college students in practice teaching and in subsequent field service. Practically all of these studies have arrived at the conclusion that such tests are of little significance. Broom (309) studied the records of student teachers in a California teachers college. He found that the highest correlation was between practice teaching marks and total equivalent scores on the Thorndike Intelligence Examination, although the correlation was only .296. He suggested, as Waddell had done earlier, that training institutions desiring to improve the quality of their product might do well to eliminate the lowest 5 percent of their applicants on the basis of a reasonable intelligence test. Cahoon (311) reviewed a considerable number of earlier studies in this field showing the slight value of psychological tests in prediction of teaching success and analyzed in another study some data from the University of California. He summarized his studies as follows (310: 227):

As far as the possibility of using intelligence test scores as a determinant in predicting success in practice teaching is concerned, there seems to be no indication from the data presented in this study that the intelligence test scores of the student teacher group are related to the degree of their possible success as practice teachers.

Frasier (319) studied the intelligence test records and teaching success of the highest and lowest 5 percent of two groups of students in a state normal

school. He found a correlation of $-.028$ between Alpha scores and student teaching. These results are even less favorable than those reported in most other studies. Frasier attributed them to the greater reliability of the tests used in other studies. He developed one point that seems to have escaped the attention of many other authors, namely, the fact that normal-school students are already a select group with respect to intelligence. With enough intelligence to graduate from high school, further intelligence seems to have little significance in ultimate success in teaching. He reviewed the older studies of Whitney and Waddell. Krieger (327) concluded that the general psychological examination can be used constructively in the guidance of those students who score very high or very low, but that the test scores have little significance in the guidance of those of mediocre ability.

Pyle (337: 261) recognized clearly the lack of relationship between psychological tests scores and teaching success. He said:

It is clear that the correlation of teaching success with intelligence scores is practically zero. But more remarkable still, the correlation between the grade received in the third course in practice teaching and later success as estimated by principals is only .146. The interpretation of this correlation is that success in practice teaching is of only slight value in predicting later success as measured by principals.

While intelligence tests enable us to predict with some success the academic records of students, they do not enable us to predict success in practice teaching nor later success in actual teaching.

Sorenson (341) made a detailed analysis of the problem. He reviewed several of the studies which stress the lack of relationship between intelligence and teaching success and pointed out that there are two important reasons for this lack. One is the intellectual homogeneity of the group and the other is the unknown reliability and validity of estimated teaching success.

Conclusion

All attempts at prediction are, in part, dependent upon a criterion which is assumed to be non-variable whether that criterion be the demands of a high-school or college course or the teaching profession. If these demands always remained constant, better progress might be made in the discovery of combinations of variable factors which would be sufficiently accurate for practical predictive purposes. But such factors do not remain constant. This, coupled with the unreliability of the measures of the factors which are known to vary, makes prediction precarious in the extreme. Of greater significance still, educationally, is the implied assumption underlying all such attempts at prediction that the criterion represents the ideal. Greater returns to society may possibly be had by changing the nature of the demands to suit the abilities of the individuals concerned, particularly in such matters as high-school or college attendance. Predictive devices are of limited value in estimating whether individual students are likely to be benefited by edu-

cational programs as they are now organized and managed, but they are even less valuable in determining whether educational programs ought to be organized and managed otherwise.

In summary, it may be said that psychological tests have great administrative usefulness, but that they are not a reliable sole basis for any administrative decision. Combined with measures of other traits and abilities, and with more or less subjective judgment of some of them, they are of value for the sectioning of classes into more or less homogeneous groups, for the selection of students for recommendation to colleges and universities, and in the prediction of academic success at higher levels.

CHAPTER VI

The Uses of Psychological Tests for Atypical Group

THE PSYCHOLOGICAL testing movement had its beginnings largely in connection with the problems of mental deficiency and abnormality. As instruments were perfected and as interest developed, tests were applied to atypical groups such as the criminal, the delinquent, and the dependent. Following their use with these special groups, tests were applied in large numbers to normal populations such as characterize the usual public-school situation. Their most recent contribution has been the discovery of children of superior intelligence, so far as their psychological characteristics are concerned. Simultaneously, attempts have been made to measure the intelligence of the blind and the deaf. Progress has been somewhat slower here because of the lack of suitable tests and because of the less universal interest in such problems. Naturally the greatest advances in psychological testing, both in point of technic and amount of work done, have occurred in connection with the normal group, but the measuring of the extreme deviates has done much to round out and clarify the concept of the nature of intelligence, the extent and character of individual differences, and the distribution of mental power throughout the entire population.

The Feeble-Minded

The use of psychological tests has brought the concept of feeble-mindedness definitely into the field of psychology and education. Before the advent of the Binet Scale, definitions of feeble-mindedness were phrased in legal, medical, or sociological terms, having but little significance for those concerned with education. Seguin became interested very early in the possibilities of education for this group. He approached the problem almost entirely from a physiological point of view. His work had considerable influence in the improvement of conditions surrounding these persons, but little progress was made in educational procedures until Binet laid the psychological foundations for such work. The early work of Binet and Norsworthy and the subsequent investigations of Hollingworth, Burt, and many others seem to indicate that the deficiencies of the feeble-minded are deficiencies of degree rather than of kind. They are subject to the same laws of learning and intellectual development as are other persons.

Medical workers still place considerable emphasis on classification according to clinical types, but the psychological types of idiot, imbecile, and moron are not definitely delimited. There is more or less difference of opinion as to the upper limit of intelligence which shall be taken as differentiating the feeble-minded from the normal.

Since there is little agreement on the level which separates the feeble-minded from the normal, estimates vary as to the number of feeble-minded persons in the total population. Pintner's (392) summary of various estimates is given in Table 1.

TABLE 1.—ESTIMATES OF THE PERCENTAGE OF FEEBLE-MINDED

Authority	Percent
British Royal Commission, 1908.....	.40
Oregon Survey, Carlisle, 1921.....	.50
United States, Bailey and Haber, 1920.....	.65
Wisconsin Schools, Cary, 1916-18.....	.70
British Mental Deficiency Commission, Report, 1929.....	.73
Oneida County, New York, Carlisle, 1918.....	.73
Porter County, Indiana, Clark, 1916.....	.90
Rural County, Ohio, Sessions, 1918.....	1.80
Rural Survey, Delaware, Mullan, 1916.....	1.80
Toronto Schools, Smith, 1920.....	2.00
Goddard's Estimate, 1914.....	2.00
Terman's Estimate, 1916.....	2.00
Cleveland Survey, Mitchell, 1916.....	3.00
Popenoe's Estimate for U. S. A., 1929.....	4.00
X. County, California, Terman, 1918.....	4.24
Eight Minnesota Towns, Kuhlmann, 1923.....	4.70
X. County, Minnesota, Anderson, 1922.....	6.10

Researches and reports bearing upon the problem of feeble-mindedness are reported annually by Pintner (393). The majority of more recent studies seems to bear upon the incidence of mental deficiency, although there is some attention to matters of clinical interest, such as the rate of mental development and constancy of mental characteristics.

Pressey and Pressey (397) discussed the relation between I. Q. and diagnosis of feeble-mindedness. It is their view that an I. Q. of 70 or below is a strong indication of feeble-mindedness. Minogue (387) found that about 72 percent of the feeble-minded remain relatively constant on retests, but of those who vary, a larger number lose than gain. Wallin (405) found that the feeble-minded scatter less on Binet Tests than do normal children, and that scattering among unstable psychopaths is not enough to constitute a reliable diagnostic sign. According to Fox (363) the feeble-minded tend to make the best showing on the same tests which are done most successfully by normal children. Differentiation between feeble-minded and normal children is more nearly shown by tasks which are more definitely of a mental character, according to Wilson (409). Bennett (350) compared pupils in special classes with children in the regular elementary schools matched for age and I. Q. She found slight differences in educational status. Physical

defects and abnormalities were somewhat more numerous among the special class group.

Lewis (366), according to Part IV of the Report of the British Mental Deficiency Committee, found that .85 percent of the children in six areas, tested with group and Binet tests, were feeble-minded or had I. Q.'s below 60. The estimated incidence of feeble-mindedness for the entire population is .73 percent, which is about double the percentage reported by the Commission in 1906. Popenoe (396) analyzed various surveys of schools and the like and estimated that 4 percent of the population fell below an I. Q. of 70. Wallin's (405) survey of special education in Baltimore showed that 24.3 percent of the white and 73.4 percent of the colored children had I. Q.'s below 68. Town (402) reported that 24 percent of 695 behavior problem cases and 20 percent of 75 unmarried mothers were feeble-minded. Bridgman's (351) report on 3,675 cases brought to a clinic showed 1.5 percent male and 1.2 percent female idiots and 5.7 percent male and 6.9 percent female imbeciles. There was a much larger number of female than male morons. Lincoln (379) found that the I. Q.'s of problem children examined at a clinic ranged from 20 to 110 with a median of 75. Willhite and others (407) found that the incidence of feeble-mindedness in South Dakota is about .5 percent of the total population. Only about one-seventh of that number are in institutions. Of some eugenic interest is the report of Martz (384) who found that ten out of twenty-five children born of low-grade mothers are of normal intelligence. Town and Hill (403) investigated the records of persons returned to the community from a state institution for the feeble-minded. These persons were supposed to be fitted for life outside the institution. About 14 percent were total economic failures.

Use of Tests in the Identification of the Subnormal

Psychological tests were first used educationally in the selection of pupils who were mentally deficient and who were to be assigned to special or auxiliary classes. This use preceded their use for purposes of general classification or for the selection of gifted pupils, doubtless due to the fact that extreme variations in individual differences were first noted and those variations at the lower end of the scale were most conspicuous. Bright pupils might easily go unobserved in a school régime gauged to the abilities of the mediocre, but dull pupils could not keep up, regardless of pressure. They naturally received the bulk of attention in the early application of psychological tests to school pupils. Pintner (392) traced the early development of school testing directed toward the identification of dull and subnormal pupils by means of individual and group tests. Hilleboe (370) reviewed the studies bearing upon the problem of diagnosis, assignment, and educational treatment of this group as well as others who may be classed as atypical. His conclusions as to the use of psychological tests in the identification of the mentally subnormal were as follows:

(1) Group tests are an economical and accurate method of discovering the mentally subnormal.

(2) Boys and girls with I. Q.'s of 85 or below, those indicated as subnormal by teachers, those who show marked irregularity in the group tests, and those who are retarded in school progress, may well be selected for further diagnosis.

(3) Individual intelligence tests should be given to all boys and girls discovered by the initial selective process.

(4) Verbal tests should be supplemented by motor tests for the linguistically handicapped, and by tests of special abilities for all those whose record indicates the desirability of such tests.

(5) The criterion of three years or more of mental retardation as a requisite for admission to special classes is unsatisfactory from the standpoint of delay in selection.

He further pointed out that test results must be combined with many other items in arriving at a true diagnosis of mental subnormality; and that, so far as school history is concerned, pupils may appear to be subnormal who are suffering from various physical handicaps. Broady (352) also reviewed many other studies in his formulation of administrative policies. His conclusions with respect to the use of tests for purposes of diagnosis and classification were not at variance with those of Hilleboe. The older books and studies which have had to do with classification and diagnosis of this group, such as those of Goddard, Wallin, Anderson, Porteus, Hollingworth, and Doll, were reviewed by both Pintner and Hilleboe in the references cited. Bennett (350) studied subnormal children in the regular elementary schools in comparison with those who had been assigned to special classes. Her purpose was primarily that of appraisal of educational status rather than the evaluation of psychological tests in selection. She found that there were no marked differences in any of the psychological characteristics of the two groups, but this seems to reflect upon the basis used in the initial recommendation for psychological examination rather than upon the validity of any of the devices used in diagnosis. In a city which does not have facilities for testing all children, it seems obvious that the more noticeable characteristics, such as physical stigmata and disciplinary troubles, would be seized upon as an indication of mental deficiency where the only other criterion was school retardation.

Use of Tests in the Identification of the Superior

Due to the concentration of attention on the measurement of the subnormal and abnormal deviate, early psychological tests were not well adapted to the discovery of superior intelligence. Measurement of persons with superior intelligence had to await the development of better scales. Partly for this reason and partly because of the fact that superior children are less conspicuous in an ordinary school situation, experimental work in measurement as well as in education has been less extensive and voluminous. Nevertheless, as Pintner (392: 350) indicated in his recent book:

. . . the child of superior intelligence has been discovered by the intelligence test. Previous to this time we have had geniuses, peculiar freaks, and extraordinary prodigies, and the connotation attaching to such words as "genius," "prodigy," "precocity," and the like, indicates that they were regarded as something apart, as something unhealthy and slightly abnormal. We have had to wait for the intelligence test to give us a better definition of superior intelligence and to show us that superior intelligence is not nearly so uncommon as we seem to have imagined.

Among early investigations in this field, the work of Whipple was probably most noteworthy. The monumental work of Terman in his *Genetic Studies of Genius* and the experimental work of Hollingworth were outstanding in the discovery that superior children are not necessarily physical weaklings, or persons of peculiar temperamental traits and anti-social habits.

Terman's (401) study of one thousand gifted children is well known. Inasmuch as it was the first investigation of large scope, the principal findings are worthy of reiteration. All the children had I. Q.'s above 140. The group of one thousand furnished a larger ratio of boys to girls than would be expected in the general population. The social status of the families of these children was much higher than the average, although there were instances of children coming from very poor families. There was a much greater proportion of distinguished relatives than would be found in the average family. These children were physically superior to the normal control group and were healthier than the normal racial stock. There were fewer cases of insanity and feeble-mindedness among relatives. As to school status, they were 14 percent of their age above the norm in grade location and 48 percent of their age above normal in intelligence. They showed no more unevenness in abilities than do normal children. They were interested in much the same sort of things, but their play interests tended to place more emphasis on activities involving thinking. They were somewhat more mature, quieter, and less sociable. Eighty-five percent of the group were above the median of normal children in character and personal traits.

Much of the material developed in recent years is summarized in Hollingworth's (371) book. In addition, Hollingworth presented data relating to several children whose I. Q.'s were above 180, and discussed the educational implications of their mental and physical characteristics. Hollingworth and Monahan (374) showed that children of superior intelligence were superior to normal children in certain motor tests and not especially lacking in any motor abilities. Similar results were obtained in their investigation of superior and normal children in jumping, chinning, and strength of grip (388). Superior children were also about as sensitive on the Seashore Musical Ability Tests as normal children of similar chronological age (372).

Cox (357) attempted to measure the mental status of historical characters. She collected the boyhood records of three hundred eminent men of history, born between 1450 and 1850, and had experts estimate their intelligence quotients. The estimates ranged from 100 to 200, with a median of 135.

Goddard (364) described the education of a group of superior children in Cleveland. The I. Q.'s of this group ranged from 108 to 172, with a median of 128. Of 244 children in this group, 127 were boys and 117 girls. Danielson (358) similarly described a special class for superior children in Los Angeles, in which the average I. Q. was 134 and about one-fourth of the class were above 140. Kiefer (376) found no difference between the means of superior and normal groups on five motor tests for ages nine, ten, and eleven, and no correlation between these tests and intelligence.

Considerable attention has been given to the subsequent careers of superior children who were the subjects of earlier studies. Hollingworth (373) reported on the mental status of an individual who ten years before had an I. Q. of 187. His status at the time of the second report was about four P. E.'s above the median level of college students on the CAVD Tests. Lincoln (378) found that a group of underage children admitted to school on the basis of mental age were above the median in achievement in grades four to seven. Witty (410) studied one hundred children with I. Q.'s above 140. After five years they showed the same superiority in physical characteristics over a control group as when first tested, but their I. Q.'s measured by the Terman Test were lower than the original Binet I. Q.'s. Lamson (377) investigated the high-school records of the group studied earlier by Hollingworth. They were significantly superior to students generally in achievement and not inferior in health. Their intelligence quotients were all above the highest decile for high-school students and more than half were at the top percentile for adults generally. Gray's study (365), mentioned in another section of this *Review*, showed that although young college students of superior mental powers did not greatly excel other students in scholastic marks, they graduated in less time and took part in a larger number of activities.

Duff (362) studied the careers of a group of children with I. Q.'s above 135. He compared them with children of normal abilities. Seven of the normal group who had subsequently entered secondary schools were found to be inferior in achievements to thirteen of the superior group who had not spent any time in secondary schools. Individuals in the control or normal group were inferior in practically all respects. Even in those points in which further education might be expected to bring any individual above the achievements of those who had stopped school earlier, no such result was achieved in this case. Duff concluded "that higher education cannot compare with innate intelligence as a differentiating force."

The most comprehensive follow-up study is that reported by Burks and others (354) in the third volume of *Genetic Studies of Genius*. After six years they found that the mean I. Q. of the younger children had decreased from a mean of 148 when first studied to 139 at the time of the second study. Most of the decreases were found among the girls. The older children were found to be in the 97th to 99th percentiles on the Terman Group Test. The

majority of all the cases were at approximately the same mental level as when first tested. Those who were students in Stanford University and those who were not had a mean score on the Thorndike Test above the university mean.

The use of psychological tests in the identification of the superior is subject to many of the same limitations which hold when they are used in the identification of the subnormal. In this case, however, psychological tests seem to be of somewhat more crucial importance because of the absence of many of the social and scholastic factors which are effective, at least in part, in establishing mental subnormality. There is often little incentive growing out of the régime of the school itself for those of superior mental power to make greater use of their abilities than is required to meet the demands set for the mediocre. It is only by the use of some diagnostic device, apart from the ordinary devices of the school room situation, that mental superiority can be identified with any degree of certainty or objectivity.

The situation with respect to the superior child is well expressed in the following quotation from Pintner (392:451).

The superior child has never been considered a problem in the schools, mainly because he has never really been recognized. He almost always can cover the required work, and, so doing, fulfills the main requirement of the school. If he is unruly or mischievous, the school can and does deal more or less effectively with this type of behavior, even though it does not recognize that it may sometimes be a symptom of superior intelligence. Again, the school greatly resents the suggestion that it cannot recognize superior intelligence, that it is necessary to have psychological tests in order to discover it. Does it not daily and monthly pile up a vast array of grades and marks, so that the sheep may be separated from the goats, so that it may reward the brightest scholars and admonish the laggards? In other words, the school has tacitly assumed that the amount of school work accomplished is a direct measure of general intelligence, and is only slowly beginning to realize the difference between educational attainment and general intelligence. Even today this distinction between knowledge and intelligence is not clear in the consciousness of the teacher. She is apt to assume that because a child has done good work in the class in which he happens to be, he is, therefore, of superior intelligence. And, conversely, if he does merely average or poor work, he is, therefore, of normal or subnormal intelligence.

In the opinion of Hilleboe (370) the application of one or more verbal intelligence tests is no more satisfactory in appraising all of the abilities which should be taken into account in developing a well-rounded program for the superior child, than for the dull. Since it is probable, however, that the emphasis in school work will be placed—and quite naturally—on those phases of education which depend upon higher powers of mental functioning, psychological tests are of paramount importance in the selection of gifted children for special classes or special attention in regular classes.

The Delinquent and Dependent

Early psychological testing of the delinquent was carried on largely in institutions; but as social workers and public agencies have concentrated

more and more on the prevention of delinquency, the use of tests in connection with courts, welfare centers, and guidance clinics has become more general. According to Pintner's (392: 392) statement, although earlier studies tended to show a large amount of feeble-mindedness among delinquents, later studies have established the fact that delinquency cannot be explained as due to any one cause.

Tests applied in detention homes, juvenile reformatories, and at behavior clinics furnish most of the data regarding the mental status of delinquents. In a study of reformatory boys, Adler (347) found that 31 percent were feeble-minded and 22 percent were of borderline mentality. Only 4.6 percent had I. Q.'s above 110. In another report (346) he analyzed the results of tests in a state school for boys and showed that Chicago boys had an average I. Q. of 82, whereas boys from other parts of the state of Illinois had an average I. Q. of 76. In a juvenile detention home, 35 percent of the cases were feeble-minded, with I. Q.'s below 70. Asher (348) found the median I. Q. of twenty reform school boys to be 67. However, these boys did about as well as the average on the Stenquist Assembly Tests. McCaulley (380) tested one hundred boys in a disciplinary school and found an I. Q. range of 57 to 117, with a median of 85. Sixteen percent were feeble-minded and 26 percent were borderline cases. Kuhlmann (386) reported that 24 to 42 percent of the inmates of five Minnesota institutions had I. Q.'s below 75. In the Whittier State School, Sullivan (400) found that entering boys had an average I. Q. of 90. She attributed this high average to the fact that definitely feeble-minded delinquent boys are sent to other institutions.

Derby (360), who tested girls at the Women's Protective Association in Cleveland, found less than 1 percent to be of superior intelligence. Normal expectancy would allow a much greater percent. The studies of McClure and Goldberg (381) and Caldwell (355) confirmed earlier reports as to the low intelligence of unmarried mothers and of inmates of industrial schools.

Merrill (385) found an average I. Q. of 82 for juvenile delinquents. According to Maris (383), 8 percent of the juvenile delinquents of Manitoba were feeble-minded and 21 percent were borderline cases. Riley (399) found that the mental age of probation boys was higher by about one year according to performance tests than when measured by the Binet Test. Coleman (356) found no difference in intelligence between problem boys and non-problem boys in high school. Riddle (398) studied clinic records to discover the relation between intelligence and stealing. The mean I. Q. of those known to steal was 78. Those who did not steal had a mean I. Q. of 70. Those who could not be classified definitely with respect to this type of offense had a mean I. Q. of 66. Delinquency of this type seems to increase with M. A. and I. Q.

In a study of adult prisoners, Adler (346) found that the distribution of I. Q.'s was rather closely comparable to the army distributions based on Army Alpha. But Murchison (389), who tested four thousand white prison-

ers, found them somewhat better on Army Alpha than the white draft. In a study of the Illinois parole system, Burgess (375) found that the most intelligent prisoners violated parole as much as, if not more than, the less intelligent prisoners.

Where delinquency is complicated by defective mentality or abnormal mental personality traits, the difficulty of achieving a satisfactory social adjustment is greatly increased according to Healy and Bronner (368). About 13.5 percent of the juvenile delinquents studied were feeble-minded. According to Healy (369), 85 percent of delinquents of normal mentality were successful in foster homes, but only 40 percent of delinquents of defective mentality were successful.

Dependency is closely related to delinquency and a common factor of defective mentality seems to characterize the two groups. Psychological tests of dependent children reported in the fourteen different studies reviewed by Pintner (392:400) showed amounts of feeble-mindedness ranging from 5.7 to 39. The same reports showed large amounts of backward mentality among dependents, ranging as high as 62 percent. Reports of mentality above normal were noticeably few in number. Psychological studies of adult dependents showed equally large amounts of inferior mentality. Davis (359) compared orphanage children in Texas with public-school children using the Dearborn Test and the Haggerty Test. According to scores on the former, there was over three times as great a percentage of orphanage children with I. Q.'s below 70 as of public-school children, and only one-seventh as great a percentage with I. Q.'s above 120. Results on the Haggerty Tests were somewhat more favorable to the orphans.

The Deaf

Outstanding work in the psychological testing of the deaf has been done by Pintner and Paterson who first attempted to use a recognized intelligence test. Table 2 shows the I. Q.'s of deaf children as determined by Day, Fusfield, and Pintner (392:411).

TABLE 2.—THE INTELLIGENCE OF DEAF CHILDREN OF VARIOUS AGES *

Deaf	Hearing equivalent	I. Q. of deaf
Age 12	Age 10	83
Age 13	Age 10-6	81
Age 14	Age 11-0	79
Age 15	Age 12-0	80

* This table is to be read as follows: The average mental age of deaf children twelve years of age is equivalent to that of hearing children ten years old, giving them an average I. Q. of 83.

Drever and Collins (361) devised a performance test with which they tested deaf children and hearing children. They found no differences between the two groups. Drever used his performance scale in testing 1,474 deaf children between five and sixteen years of age and found the deaf children slightly above the median for hearing children. Pintner (395) found no correlation between measures of speech or speech reading and the Pintner Non-Language Test, but fair correlation between speech reading and an educational test. Tests of deaf pupils with the Pintner Non-Language Test and the Arthur Performance Scale, made by Brown (353), gave a correlation of .80 which was reduced to .61 when chronological age was held constant. Williams (408) gave the Goodenough Drawing Test to a group of deaf pupils. The mean I. Q. for the group was 79.5, with about one-fourth of the subjects below 70. Pintner (394) tested four thousand deaf children with the Pintner Non-Language Test. His results showed a very marked retardation both of intelligence and achievement on the part of deaf children.

Upshall (404) studied 311 matched pairs of deaf children in day schools and institutions. He found the brighter children in the day schools. He first attributed the difference to the fact that day-school pupils have more residual hearing and become deaf later; but even when these factors were equated, the day pupils were superior in achievement.

Madden (382) compared hard-of-hearing children in regular public schools with hearing children of the same age, sex, race, and parental occupation. He found a difference of 6.42 in I. Q. in favor of the hearing children. From an analysis of individual test items of the Binet Test he concluded that hard-of-hearing children do not have verbal handicaps that are not also characteristic of hearing children. A correlation of $-.123$ between intelligence and auditory loss was obtained after eliminating the factor of age.

The Blind

Pioneer work in psychological testing of the blind was done in Cleveland by Irwin (392:426). A comparative study made by Hayes of 670 blind children and 1,000 unselected sighted children tested by Terman gave the distribution of intelligence shown in Table 3 (392:427).

More recent studies have not modified these findings appreciably. Hayes (367) reported that on tests suitable for both seeing and blind, the blind were ten points in I. Q. below the seeing. Myers (390) made a survey of sight-saving classes and found that 58.9 percent of the cases tested had I. Q.'s lower than 90 and that only 9.4 percent ranked higher than 110. Pintner (392:430) summarized the work that has been done with the blind as follows:

A very good beginning has been made in the intelligence testing of the blind. Enough research work has been done on the construction of scales so that useful methods of measurement exist. The results of the tests so far published show the blind as a group somewhat inferior mentally to the sighted. There is evidently a large percentage of feeble-mindedness among the blind. . . . The difficulty of acquiring language is not nearly so great among the blind as among the deaf, because the former learn to speak and talk easily and normally, just as a normal hearing-seeing child does. Lastly, there is no evidence that compensation for the handicap of blindness exists in the form of increased sensitivity of touch, hearing, or of a better memory ability.

TABLE 3.—PERCENTAGES OF BLIND AND SIGHTED CHILDREN AT VARYING LEVELS OF INTELLIGENCE

Classification	Percentage found among	
	The blind	The sighted
Genius	0.3	0.5
Very superior	1.	2.
Superior	5.	9.
Average	68.	76.
Dull	12.	8.
Borderline	7.	2.
Feeble-minded	5.	0.3

Speech Defects

Barnard (349) reviewed thirty-two studies bearing upon the relation of intelligence and other factors to defective speech. His conclusions based upon this review were as follows:

- (1) Low intelligence frequently accompanies delayed speech and language difficulties. In some cases, low intelligence accompanies stuttering. . . .
- (2) A study of stutterers shows them to possess every degree of intelligence. . . .
- (3) The studies show a wide range of intelligence from low to high with no uniform rating. This conclusion applies to persons suffering from all classes of speech defects and is the same as the conclusion for stutterers alone.
- (4) The use of intelligence tests may be helpful in indicating symptoms of speech defects but not in locating their causes.

Physical Defects and Abnormalities

Investigations of the relation between intelligence and bodily condition were reviewed critically by Paterson (391). He devoted attention particularly to a review and criticism of the evidence of the effect of diseased and abnormal conditions, malnutrition, and the like, on mental efficiency. Summarizing the evidence available Paterson (391:211-12, 269) said:

On the basis of available evidence the notions that dire mental consequences may arise from physical defects and poor physical condition have been and still are greatly exaggerated. Such consequences as exist are demonstrable for mankind in the mass only to a slight degree.

With the exception of diseases and injuries directly involving the central nervous system itself, it would appear that we cannot explain the tremendous range of individual differences in intellect on the hypothesis that unfavorable physical condition or specific physical defects are operative as a major causal factor. Apparently nature has so safeguarded the central nervous system as to render normal mental development relatively secure or at least strongly immune to such deleterious influences as malnutrition, diseased tonsils, enlarged adenoids, defective breathing, defective teeth, simple goiter, intestinal toxemia, and even hookworm. . . .

It appears that such structural characteristics as height and weight are correlated only slightly with intelligence, narrowly defined. Even measurements of head size and shape are found to be relatively independently variable with respect to intellect, and skeletal development measured by precise X-ray photography yields either zero or low correlations with intelligence. The same may be said of dentition. Physiological development, measured in terms of pubescence, is found to be relatively unrelated to mental development, and so are complicated morphological indexes of body build.

Paterson also reviewed the bearing of the evidence he had assembled on the problem of individual differences and the nature-nurture conflict. His evidence and his conclusions contain little solace for the environmentalists. The entire study showed that Paterson agreed with Pearson, from whom he quoted as follows (391:289) :

Intelligence as distinct from knowledge stands out as a congenital character. Let us admit finally that the mind of man is for the most part a congenital product, and the factors which determine it are racial and familial; we are not dealing with a mutable characteristic capable of being moulded by the doctor, the teacher, the parent, or the home environment. These may provide the material upon which it can act, and give a welcome scope for its activities, but they do not create it.

The Report of the Committee on Special Education of the White House Conference on Child Health and Protection (406) is the most recent and comprehensive statement of the needs of atypical groups.

Summary

On the basis of an intellectual criterion of differentiation, this chapter has reviewed studies dealing with the feeble-minded and with those of superior intelligence. Studies of feeble-mindedness have dealt largely with its incidence in the total population and with the amount of feeble-mindedness in certain behavior groups. Estimates of feeble-mindedness in the total population vary from .4 percent to 6.1 percent. Interest in the superior is a recent development in education encouraged principally by the derivation and use of psychological tests. It has been demonstrated that gifted students are often as superior in all other desirable traits as in intelligence. Evidence that there is some tendency for the superior to regress toward the normal population at a later age is somewhat disquieting, but this apparent tendency may be due to absence of valid and reliable measures of highly developed personality traits or comparative achievement at later periods.

The groups selected for study on the basis of a non-intellectual criterion of differentiation include the dependent and delinquent, the blind, the deaf, those with speech defects, and those with physical handicaps and abnormalities. The long established belief that dependency and delinquency were *prima facie* evidence of defective mentality is decidedly challenged by the studies reviewed. Although there is a noticeable lack of superior intelligence among the delinquent, this may be due to the peculiar social and legal conditions under which delinquent persons come to the attention of psychological investigators. There is considerable evidence that the amount of defective mentality among the delinquent groups has been greatly overestimated, and that it may not be substantially greater than is to be found in the population at large. The dependent as a special group, aside from considerations of delinquency, is rather definitely characterized by abnormally large amounts of defective mentality.

Most studies indicate that both the blind and the deaf may be expected to reveal inferior intelligence, at least insofar as their behavior may be compared validly with that of sighted and hearing persons. Nevertheless, little has been accomplished by way of measuring the intelligence of such persons in terms of a behavior criterion which takes into account the sensory defects themselves. Speech defects are not definitely identified with particular levels of intelligence.

Neither gross physical characteristics nor abnormal or pathological physical conditions, except those directly affecting the central nervous system, show any significant relation to mental efficiency.

CHAPTER VII

Vocational Aptitudes Tests and Their Applications

VOCATIONAL tests are being examined both critically and uncritically to a greater extent than heretofore. In public intermediate and high schools, in colleges, in business and industrial centers, and in child guidance clinics questions are being raised about individual abilities, attitudes, and interests. Vocational tests, which are concerned with special and more or less separate abilities, will doubtless answer many of these questions.

Historical Résumé

Hugo Münsterberg (433) may be regarded as the first advocate of vocational tests as such in the United States. In Germany the movement is well covered in Giese's (424) exhaustive treatise of tests and in Baumgarten's (415) historical sketch. In France the work of Lahy in Paris is outstanding, but French scholars have been slow to approach the field of applied psychology. In England the National Institute of Industrial Psychology has done a great deal of work with private enterprises and with schools. Cox (420), Earle and Macrae (422), Myers, and Muscio also made valuable contributions. With reference to work in Switzerland, the names of Claperede, Walther, and Ehinger should be mentioned. Work in Russia was described by Baumgarten (414).

Hugo Münsterberg was invited to become director of the Harvard psychological laboratory in 1892 at the instance of William James. His background caused him to take great interest in the life of the American people. His books indicate the range of his interests, including such problems as the application of psychology to criminal law, to psychotherapy, to education, and to industry. In 1911-12 he investigated several of the largest manufacturing concerns, and sent out a circular to one thousand leading companies, asking what some of the mental traits required of employees were. His purpose was to determine a principle by which any candidate for any industrial job might be tested at any time. He tested telephone girls for memory, attention, intelligence, exactitude, and rapidity. He tested street-car motormen and ship pilots. His two books that concern themselves the most with vocational tests are *Psychology and Industrial Efficiency* and *Vocation and Learning*. Without attempting to evaluate Münsterberg's work we can say that it aroused much interest and suggested numerous possibilities.

Link (429) devised a number of tests and tried them out under actual working conditions during the period of the World War. However, the

testing program of the United States army, which gave great impetus to the development of intelligence tests and trade tests, contributed relatively little toward vocational tests as such. These have been developed, for the most part, during the post-war period.

Vocational Tests

Any classification of vocational tests is somewhat arbitrary. A test may or may not be "vocational" depending on the purpose to which it is put. Thus a measure of "height," which may be intended for any number of purposes, becomes a vocational test when, as one measure of individual differences, it is included in a battery of tests used in vocational guidance. For the purposes of this review the most practical grouping seems to be (1) mechanical tests, (2) manual tests, (3) clerical tests, and (4) miscellaneous tests, including those for special ability in art and music. The tests listed are merely representative of the work that is being done. It is hoped that individuals interested in the vocational testing movement will find suggestions helpful to them in a more thorough study of the field.

Mechanical tests—The Stenquist Tests (441) of mechanical ability are perhaps the best known. They were devised by Dr. John Stenquist and applied to several hundred students in the New York public schools. The Stenquist Tests were used in the army (449); by Toops (444) with 145 boys of ages twelve through fifteen; by Scudder and Raubenheimer (438) with 114 boys in the seventh and eighth grades of a junior high school; and by Commins (419) with 206 individuals (men and women) in a teacher-training school in which the ages ranged from seventeen to twenty-one. Modifications of the Stenquist Test were used by Earle and Macrae (422) and by Paterson, Elliott, and others (434).

Cox (420) approached the analysis of mechanical ability from a different angle. He first used the Stenquist Assembly Test and gave it up because "the tests showed little correlation with each other, and were found to involve a certain degree of digital strength and skill." He then devised a series of models which called for no manipulation. Certain mechanical movements were observed and then analyzed by the subject. The tests were given to two groups of untrained subjects, 88 students at a commercial school and 114 students in an elementary school; and to one group of trained subjects, 228 students in a technical school. The ages ranged from ten years to adulthood. The particular feature of the Cox Tests is the separation of the factor of ingenuity from that of manipulation.

Stine (442) used a so-called "measurement test" of his own design with 160 full-time students in the eighth, ninth, and tenth grades and compared the results with the Minnesota Revision of the Stenquist Test and with results from a test of general intelligence. A gain in scores with training was observed but no correlation figures were presented in the

study. He compared shop students with non-shop students and found that the average Minnesota-Stenquist Score for shop students was only 7.2 points above the non-shop average. On the Stine Test the difference was 1.8 points in favor of the shop group. The average I. Q. of the shop group was 2.8 points below the non-shop group.

The 586-page volume by Paterson, Elliott, and others (434) is the most thorough-going study of mechanical ability yet published. Preliminary tests were given to 217 junior high-school boys, eleven hours being required for all the tests. Seven tests were selected for the experiment proper and given to 150 boys of a "new entering class," supposedly of the 7-B grade. Additional factors considered were (1) academic success; (2) previous experience in mechanical work; (3) interests, occupational and academic; (4) motor ability, e. g., agility and gymnasium success; (5) height, weight, and vital capacity; (6) social and economic status; and (7) home influences. Of the seven tests three proved the most successful: spatial relations, paper form board, and assembly. These tests are identified as the Minnesota Mechanical Ability Tests.

Link (429) described the use of three tests with thirty-five men: the Stenquist Assembly Test, a form board of his own design, and a cube assembly test. The correlations with foremen's ratings were over .80 but the number of cases was too small for generalization. Link's work is marked by his attention to such qualitative factors as rhythm and attitude and by his use of actual shop situations. Many tests for vocational selection are described in his book.

Keane and O'Connor (428) described a measure of mechanical aptitude, consisting of a rectangular prism of wood cut into nine wiggly pieces. To administer the test, the dissembled parts are presented to the subject for assembly. It was given to 868 unselected persons in a large industry. Of these persons 44 engineers, 114 mechanics, and 81 draftsmen scored considerably above the unselected group. Three hundred applicants for mechanical occupations were tested and assigned mechanical work. Within six months 74 percent of the D grade men, but only 31 percent of those who rated A, left their jobs. The tests are described in more detail by O'Connor in a separate volume.

Baker and Crockett (413) devised a mechanical aptitudes group test that is regularly used in the Detroit schools. Considerable unpublished material on mechanical ability is available in the Detroit Psychological Clinic.

Manual-motor tests—The early literature on manual or motor tests was reviewed by Whipple (448). Link (429) used a number of tests of the manual type, including, in particular, a form board and a revolving dial for serial movement. A wealth of German material on motor tests was described by Giese (424). The Gilbreths (425) made important contribu-

tions to a knowledge of manual skill, primarily from the standpoint of industrial efficiency. Hull (427) discussed in detail the theoretical considerations underlying manual or motor ability, and included references to McFarlane (430) and Perrin (435). MacQuarrie (431) described a test of mechanical ability that is essentially the task of guiding a pencil through various motor performances. Paterson, Elliott, and others (434) included several manual-motor tests in the mechanical ability battery. In particular they extended the Link Form Board into a more reliable test. The excellent bibliography in their volume refers to a number of other manual-motor tests. Crockett (421) described a measure of manual ability which was given to over one thousand individuals in the Detroit schools and correlated with employee performances in several industries.

Clerical tests—Rogers (436) examined forty-five subjects taking stenographic work at Columbia University, using the Woodworth-Wells Test and the Trabue Language Tests. Tuttle (445) tested twenty students in beginning typewriting, and found tests of "motor action," attention and accuracy, and substitution the most successful. Bills (417) tested 139 subjects who were taking a night-school course in stenography and were also employed. She used a general intelligence test, a special aptitude test composed of five parts, and a will-temperament test of ten parts. Link (429) used a test for spelling, substitution, and sentence completion. These or relevant tests were given to 300 seniors in a commercial high school, 76 pupils in two business schools, 22 office typists, 19 stenographers, over 400 candidates for typing and stenographic positions, 140 comptometrists, and to more than 120 candidates for comptometry. Thurstone (443) devised tests for typists and stenographers but the test manual includes no data as to subjects tested. Yoakum and Bills (450) presented an excellent overview of tests for office occupations including (1) general ability tests, (2) special aptitude tests, and (3) proficiency or trade tests.

Miscellaneous tests—The technics involved in vocational testing are described by Griffiths (426), Hull (427), Bingham and Freyd (418), Link (429), and others. Tests of music and drawing aptitude are described by Seashore (439), Stanton (440), Ayer (412), Fischlovitz (423), and Manuel (432). Two excellent bibliographies on psychology in industry have been prepared by Viteles (447), who is one of the best informed industrial psychologists in the United States.

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